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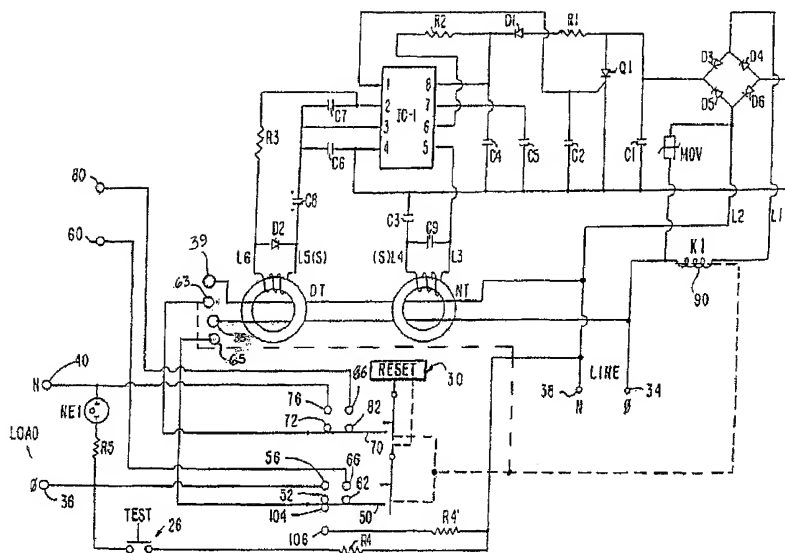
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(57) Abstract: Resettable circuit interrupting devices, such as GFCI devices, that include reverse wiring protection, and optionally an independent trip portion and/or a reset lockout portion are provided. The reverse wiring protection operates at both the line and load sides of the device so that, in the event line side wiring to the device is improperly connected to the load side, fault protection for the device remains. The trip portion operates independently of a circuit interrupting portion used to break the electrical continuity in one or more conductive paths in the device. The reset lockout portion prevents the reestablishing of electrical continuity in open conductive paths if the circuit interrupting portion is non-operational or if an open neutral condition exists.



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## **CIRCUIT INTERRUPTING DEVICE WITH REVERSE WIRING PROTECTION**

### 5    Technical Field

The present application is directed to reset lockout devices including resettable circuit interrupting devices and systems such as ground fault circuit interrupters (GFCI's), arc fault circuit interrupters (AFCI's), immersion detection circuit interrupters (IDCI's), appliance leakage circuit interrupters (ALCI's), equipment leakage circuit  
10 interrupters (ELCI's), circuit breakers, contactors, latching relays and solenoid mechanisms.

### Description of the Related Art

Many electrical wiring devices have a line side, which is connectable to an electrical power supply, and a load side, which is connectable to one or more loads and  
15 at least one conductive path between the line and load sides. Electrical connections to wires supplying electrical power or wires conducting electricity to the one or more loads are at line side and load side connections. The electrical wiring device industry has witnessed an increasing call for circuit breaking devices or systems which are designed to interrupt power to various loads, such as household appliances, consumer electrical  
20 products and branch circuits. In particular, electrical codes require electrical circuits in home bathrooms and kitchens to be equipped with ground fault circuit interrupters (GFCI), for example. Presently available GFCI devices, such as the device described in commonly owned U.S. Patent 4,595,894, use an electrically activated trip mechanism to mechanically break an electrical connection between the line side and the load side.  
25 Such devices are resettable after they are tripped by, for example, the detection of a ground fault. In the device discussed in the '894 patent, the trip mechanism used to cause the mechanical breaking of the circuit (i.e., the conductive path between the line and load sides) includes a solenoid (or trip coil). A test button is used to test the trip mechanism and circuitry used to sense faults, and a reset button is used to reset the  
30 electrical connection between line and load sides.

However, instances may arise where an abnormal condition, caused by for example a lightning strike, occurs which may result not only in a surge of electricity at the device and a tripping of the device but also a disabling of the trip mechanism used to cause the mechanical breaking of the circuit. This may occur without the knowledge of the user. Under such circumstances an unknowing user, faced with a GFCI which has tripped, may press the reset button which, in turn, will cause the device with an inoperative trip mechanism to be reset without the ground fault protection available.

Further, an open neutral condition, which is defined in Underwriters Laboratories (UL) Standard PAG 943A, may exist with the electrical wires supplying electrical power to such GFCI devices. If an open neutral condition exists with the neutral wire on the line (versus load) side of the GFCI device, an instance may arise where a current path is created from the phase (or hot) wire supplying power to the GFCI device through the load side of the device and a person to ground. In the event that an open neutral condition exists, current GFCI devices, which have tripped, may be reset even though the open neutral condition may remain.

Commonly owned application Serial No. 09/138,955, filed August 24, 1998, which is incorporated herein in its entirety by reference, describes a family of resettable circuit interrupting devices capable of locking out the reset portion of the device if the circuit interrupting portion is non-operational or if an open neutral condition exists. Commonly owned application Serial No. 09/175,228, filed September 20, 1998, which is incorporated herein in its entirety by reference, describes a family of resettable circuit interrupting devices capable of locking out the reset portion of the device if the circuit interrupting portion is non-operational or if an open neutral condition exists and capable of breaking electrical conductive paths independent of the operation of the circuit interrupting portion.

Some of the circuit interrupting devices described above have a user accessible load side connection in addition to the line and load side connections. The user accessible load side connection includes one or more connection points where a user can externally connect to electrical power supplied from the line side. The load side connection and user accessible load side connection are typically electrically connected together. An example of such a circuit interrupting device is a GFCI receptacle, where the line and load side connections are binding screws and the user accessible load side

connection is the plug connection. As noted, such devices are connected to external wiring so that line wires are connected to the line side connection and load side wires are connected to the load side connection. However, instances may occur where the circuit interrupting device is improperly connected to the external wires so that the load wires  
5 are connected to the line side connection and the line wires are connected to the load connection. This is known as reverse wiring. In the event the circuit interrupting device is reverse wired, fault protection to the user accessible load connection may be eliminated, even if fault protection to the load side connection remains.

#### Disclosure of Invention

10 The present application relates to a family of resettable circuit interrupting devices that maintains fault protection for the circuit interrupting device even if the device is reverse wired.

In one embodiment, the circuit interrupting device includes a housing and phase and neutral conductive paths disposed at least partially within the housing between line and load sides. Preferably, the phase conductive path terminates at a first connection  
15 capable of being electrically connected to a source of electricity, a second connection capable of conducting electricity to at least one load and a third connection capable of conducting electricity to at least one user accessible load. Similarly, the neutral conductive path, preferably, terminates at a first connection capable of being electrically  
20 connected to a source of electricity, a second connection capable of providing a neutral connection to the at least one load and a third connection capable of providing a neutral connection to the at least one user accessible load.

The circuit interrupting device also includes a circuit interrupting portion that is disposed within the housing and configured to cause electrical discontinuity in one or  
25 both of the phase and neutral conductive paths, between said line side and said load side upon the occurrence of a predetermined condition. A reset portion is disposed at least partially within the housing and is configured to reestablish electrical continuity in the open conductive paths.

Preferably, the phase conductive path includes a plurality of contacts that are  
30 capable of opening to cause electrical discontinuity in the phase conductive path and

closing to reestablish electrical continuity in the phase conductive path, between said line and load sides. The neutral conductive path also includes a plurality of contacts that are capable of opening to cause electrical discontinuity in the neutral conductive path and closing to reestablish electrical continuity in the neutral conductive path, between said  
5 line and load sides. In this configuration, the circuit interrupting portion causes the plurality of contacts of the phase and neutral conductive paths to open, and the reset portion causes the plurality of contacts of the phase and neutral conductive paths to close.

One embodiment for the circuit interrupting portion uses an electro-mechanical  
10 circuit interrupter to cause electrical discontinuity in the phase and neutral conductive paths, and sensing circuitry to sense the occurrence of the predetermined condition. For example, the electro-mechanical circuit interrupter include a coil assembly, a movable plunger attached to the coil assembly and a banger attached to the plunger. The movable plunger is responsive to energizing of the coil assembly, and movement of the plunger is  
15 translated to movement of said banger. Movement of the banger causes the electrical discontinuity in the phase and/or neutral conductive paths.

The circuit interrupting device may also include reset lockout portion that prevents the reestablishing of electrical continuity in either the phase or neutral conductive path or both conductive paths, unless the circuit interrupting portion is  
20 operating properly. That is, the reset lockout prevents resetting of the device unless the circuit interrupting portion is operating properly. In embodiments where the circuit interrupting device includes a reset lockout portion, the reset portion may be configured so that at least one reset contact is electrically connected to the sensing circuitry of the circuit interrupting portion, and that depression of a reset button causes at least a portion  
25 of the phase conductive path to contact at least one reset contact. When contact is made between the phase conductive path and the at least one reset contact, the circuit interrupting portion is activated so that the reset lockout portion is disabled and electrical continuity in the phase and neutral conductive paths can be reestablished.

The circuit interrupting device may also include a trip portion that operates  
30 independently of the circuit interrupting portion. The trip portion is disposed at least partially within the housing and is configured to cause electrical discontinuity in the phase and/or neutral conductive paths independent of the operation of the circuit

interrupting portion. In one embodiment, the trip portion includes a trip actuator accessible from an exterior of the housing and a trip arm preferably within the housing and extending from the trip actuator. The trip arm is preferably configured to facilitate mechanical breaking of electrical continuity in the phase and/or neutral conductive paths, if the trip actuator is actuated. Preferably, the trip actuator is a button. However, other known actuators are also contemplated.

### Brief Description of the Drawings

Preferred embodiments of the present application are described herein with reference to the drawings in which similar elements are given similar reference characters, wherein:

Fig. 1 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present application;

Fig. 2 is side elevational view, partly in section, of a portion of the GFCI device shown in Fig. 1, illustrating the GFCI device in a set or circuit making position;

Fig. 3 is an exploded view of internal components of the circuit interrupting device of Fig. 1;

Fig. 4 is a plan view of portions of electrical conductive paths located within the GFCI device of Fig. 1;

Fig. 5 is a partial sectional view of a portion of a conductive path shown in Fig. 4;

Fig. 6 is a partial sectional view of a portion of a conductive path shown in Fig. 4;

Fig. 7 is a side elevational view similar to Fig. 2, illustrating the GFCI device in a circuit breaking or interrupting position;

Fig. 8 is a side elevational view similar to Fig. 2, illustrating the components of the GFCI device during a reset operation;

Figs. 9-11 are schematic representations of the operation of one embodiment of the reset portion of the present application, illustrating a latching member used to make an electrical connection between line and load connections and to relate the reset portion of the electrical connection with the operation of the circuit interrupting portion;

Fig. 12 is a schematic diagram of a circuit for detecting ground faults and resetting the GFCI device of Fig. 1;

Fig. 12A is a schematic diagram of a circuit for detecting ground faults and resetting the GFCI of Fig. 1 using floating movable bridges;

Fig. 12B is another schematic diagram of a circuit for detecting ground faults and resetting the GFCI of Fig. 1 using floating movable bridges;

5 Fig. 12C is a perspective view of an arrangement for a floating movable bridge electrically isolated from the line, load and face terminals;

Fig. 12D is a side view of the line, load and face terminal contacts positioned in stacked fashion and can be engaged by the lifter of the GFCI shown in the tripped condition;

10 Fig. 12E is Fig. 12D when the GFCI has been reset;

Fig. 13 is a perspective view of an alternative embodiment of a ground fault circuit interrupting device according to the present application;

Fig. 14 is side elevational view, partly in section, of a portion of the GFCI device shown in Fig. 13, illustrating the GFCI device in a set or circuit making position;

15 Fig. 15 is a side elevational view similar to Fig. 14, illustrating the GFCI device in a circuit breaking position;

Fig. 16 is a side elevational view similar to Fig. 14, illustrating the components of the GFCI device during a reset operation;

20 Fig. 17 is an exploded view of internal components of the GFCI device of Fig. 13;

Fig. 18 is a schematic diagram of a circuit for detecting ground faults and resetting the GFCI device of Fig. 13;

25 Fig. 19 is side elevational view, partly in section, of components of a portion of the alternative embodiment of the GFCI device shown in Fig. 13, illustrating the device in a set or circuit making position;

Fig. 20 is a side elevational view similar to Fig. 19, illustrating of the device in a circuit breaking position; and

Fig. 21 is a block diagram of a circuit interrupting system according to the present application.



### Best Mode for Carrying Out the Invention

The present application contemplates various types of circuit interrupting devices that are capable of breaking at least one conductive path at both a line side and a load side of the device. The conductive path is typically divided between a line side that connects to supplied electrical power and a load side that connects to one or more loads. As noted, the various devices in the family of resettable circuit interrupting devices include: ground fault circuit interrupters (GFCI's), arc fault circuit interrupters (AFCI's), immersion detection circuit interrupters (IDCI's), appliance leakage circuit interrupters (ALCI's) and equipment leakage circuit interrupters (ELCI's).

For the purpose of the present application, the structure or mechanisms used in the circuit interrupting devices, shown in the drawings and described hereinbelow, are incorporated into a GFCI receptacle suitable for installation in a single-gang junction box used in, for example, a residential electrical wiring system. However, the mechanisms according to the present application can be included in any of the various devices in the family of resettable circuit interrupting devices.

The GFCI receptacles described herein have line and load phase (or power) connections, line and load neutral connections and user accessible load phase and neutral connections. The connections permit external conductors or appliances to be connected to the device. These connections may be, for example, electrical fastening devices that secure or connect external conductors to the circuit interrupting device, as well as conduct electricity. Examples of such connections include binding screws, lugs, terminals and external plug connections.

In one embodiment, the GFCI receptacle has a circuit interrupting portion, a reset portion and a reset lockout. This embodiment is shown in Figs. 1-12. In another embodiment, the GFCI receptacle is similar to the embodiment of Figs. 1-12, except the reset lockout is omitted. Thus, in this embodiment, the GFCI receptacle has a circuit interrupting portion and a reset portion, which is similar to those described in Figs. 1-12. In another embodiment, the GFCI receptacle has a circuit interrupting portion, a reset portion, a reset lockout and an independent trip portion. This embodiment is shown in Figs. 13-20.

In yet another embodiment (see FIGS. 12A), the GFCI receptacle has a movable bridge contact that is floating allowing the line terminals, load terminals and user accessible terminals (i.e., face terminals) to be electrically isolated from each other when the GFCI is tripped; the electrical isolation between these terminals is complete in that there are no conductive paths electrically connecting any terminal to any other terminal when the GFCI device has been tripped.

In yet a further embodiment (see FIGS. 12D, 12E) the GFCI receptacle is designed so that the line, load and face terminals are positioned in a fashion allowing them to electrically connect to each other when at least one of them is engaged by an actuator.

The circuit interrupting and reset portions described herein preferably use electro-mechanical components to break (open) and make (close) one or more conductive paths between the line and load sides of the device. However, electrical components, such as solid state switches and supporting circuitry, may be used to open and close the conductive paths.

Generally, the circuit interrupting portion is used to automatically break electrical continuity in one or more conductive paths (i.e., open the conductive path) between the line and load sides upon the detection of a fault, which in the embodiments described is a ground fault. The reset portion is used to close the open conductive paths.

In the embodiments including a reset lockout, the reset portion is used to disable the reset lockout, in addition to closing the open conductive paths. In this configuration, the operation of the reset and reset lockout portions is in conjunction with the operation of the circuit interrupting portion, so that electrical continuity in open conductive paths cannot be reset if the circuit interrupting portion is non-operational, if an open neutral condition exists and/or if the device is reverse wired.

In the embodiments including an independent trip portion, electrical continuity in one or more conductive paths can be broken independently of the operation of the circuit interrupting portion. Thus, in the event the circuit interrupting portion is not operating properly, the device can still be tripped.

The above-described features can be incorporated in any resettable circuit interrupting device, but for simplicity the descriptions herein are directed to GFCI receptacles.

Turning now to Fig. 1, the GFCI receptacle 10 has a housing 12 consisting of a relatively central body 14 to which a face or cover portion 16 and a rear portion 18 are removably secured. The face portion 16 has entry ports 20 and 21 for receiving normal or polarized prongs of a male plug of the type normally found at the end of a lamp or appliance cord set (not shown), as well as ground-prong-receiving openings 22 to  
5 accommodate a three-wire plug. The receptacle also includes a mounting strap 24 used to fasten the receptacle to a junction box.

A test button 26 extends through opening 28 in the face portion 16 of the housing 12. The test button is used to activate a test operation, that tests the operation of the  
10 circuit interrupting portion (or circuit interrupter) disposed in the device. The circuit interrupting portion, to be described in more detail below, is used to break electrical continuity in one or more conductive paths between the line and load side of the device. A reset button 30 forming a part of the reset portion extends through opening 32 in the face portion 16 of the housing 12. The reset button is used to activate a reset operation,  
15 which reestablishes electrical continuity in the open conductive paths.

Electrical connections to existing household electrical wiring are made via binding screws 34 and 36, where screw 34 is an input (or line) phase connection, and screw 36 is an output (or load) phase connection. It should be noted that two additional binding screws 38 and 40 (seen in Fig. 3) are located on the opposite side of the  
20 receptacle 10. These additional binding screws provide line and load neutral connections, respectively. A more detailed description of a GFCI receptacle is provided in U.S. Patent 4,595,894, which is incorporated herein in its entirety by reference. It should also be noted that binding screws 34, 36, 38 and 40 are exemplary of the types of wiring terminals that can be used to provide the electrical connections. Examples of  
25 other types of wiring terminals include set screws, pressure clamps, pressure plates, push-in type connections, pigtails and quick-connect tabs.

Referring to Figs. 2-6, the conductive path between the line phase connection 34 and the load phase connection 36 includes contact arm 50 which is movable between stressed and unstressed positions, movable contact 52 mounted to the contact arm 50,  
30 contact arm 54 secured to or monolithically formed into the load phase connection 36 and fixed contact 56 mounted to the contact arm 54. The user accessible load phase connection for this embodiment includes terminal assembly 58 having two binding

terminals 60 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line phase connection 34 and the user accessible load phase connection includes, contact arm 50, movable contact 62 mounted to contact arm 50, contact arm 64 secured to or monolithically formed into terminal assembly 58, and fixed contact 66 mounted to contact arm 64. These conductive paths are collectively called the phase conductive path.

Similarly, the conductive path between the line neutral connection 38 and the load neutral connection 40 includes, contact arm 70 which is movable between stressed and unstressed positions, movable contact 72 mounted to contact arm 70, contact arm 74 secured to or monolithically formed into load neutral connection 40, and fixed contact 76 mounted to the contact arm 74. The user accessible load neutral connection for this embodiment includes terminal assembly 78 having two binding terminals 80 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line neutral connection 38 and the user accessible load neutral connection includes, contact arm 70, movable contact 82 mounted to the contact arm 70, contact arm 84 secured to or monolithically formed into terminal assembly 78, and fixed contact 86 mounted to contact arm 84. These conductive paths are collectively called the neutral conductive path.

Referring to Fig. 2, the circuit interrupting portion has a circuit interrupter and electronic circuitry capable of sensing faults, e.g., current imbalances, on the hot and/or neutral conductors. In a preferred embodiment for the GFCI receptacle, the circuit interrupter includes a coil assembly 90, a plunger 92 responsive to the energizing and de-energizing of the coil assembly and a banger 94 connected to the plunger 92. The banger 94 has a pair of banger dogs 96 and 98 which interact with a movable latching members 100 used to set and reset electrical continuity in one or more conductive paths. The coil assembly 90 is activated in response to the sensing of a ground fault by, for example, the sense circuitry shown in Fig. 12. Fig. 12 shows conventional circuitry for detecting ground faults that includes a differential transformer that senses current imbalances.

The reset portion includes reset button 30, the movable latching members 100 connected to the reset button 30, latching fingers 102 and reset contacts 104 and 106 that temporarily activate the circuit interrupting portion when the reset button is depressed, when in the tripped position. Preferably, the reset contacts 104 and 106 are normally

open momentary contacts. The latching fingers 102 are used to engage side R of each contact arm 50,70 and move the arms 50,70 back to the stressed position where contacts 52,62 touch contacts 56,66, respectively, and where contacts 72,82 touch contacts 76,86, respectively.

5       The movable latching members 102 are, in this embodiment, common to each portion (i.e., the circuit interrupting, reset and reset lockout portions) and used to facilitate making, breaking or locking out of electrical continuity of one or more of the conductive paths. However, the circuit interrupting devices according to the present application also contemplate embodiments where there is no common mechanism or member between each portion or between certain portions. Further, the present application also contemplates using circuit interrupting devices that have circuit  
10       interrupting, reset and reset lockout portions to facilitate making, breaking or locking out of the electrical continuity of one or both of the phase or neutral conductive paths.

15       In the embodiment shown in Fig. 2 and 3, the reset lockout portion includes latching fingers 102 which after the device is tripped, engages side L of the movable arms 50,70 so as to block the movable arms 50,70 from moving. By blocking movement of the movable arms 50,70, contacts 52 and 56, contacts 62 and 66, contacts 72 and 76 and contacts 82 and 86 are prevented from touching. Alternatively, only one of the movable arms 50 or 70 may be blocked so that their respective contacts are prevented  
20       from touching. Further, in this embodiment, latching fingers 102 act as an active inhibitor that prevents the contacts from touching. Alternatively, the natural bias of movable arms 50 and 70 can be used as a passive inhibitor that prevents the contacts from touching.

25       Referring now to Figs. 2 and 7-11, the mechanical components of the circuit interrupting and reset portions in various stages of operation are shown. For this part of the description, the operation will be described only for the phase conductive path, but the operation is similar for the neutral conductive path, if it is desired to open and close both conductive paths. In Fig. 2, the GFCI receptacle is shown in a set position where movable contact arm 50 is in a stressed condition so that movable contact 52 is in  
30       electrical engagement with fixed contact 56 of contact arm 54. If the sensing circuitry of the GFCI receptacle senses a ground fault, the coil assembly 90 is energized to draw plunger 92 into the coil assembly 90 so that banger 94 moves upwardly. As the banger

moves upwardly, the banger front dog 98 strikes the latch member 100 causing it to pivot in a counterclockwise direction C (seen in Fig. 7) about the joint created by the top edge 112 and inner surface 114 of finger 110. The movement of the latch member 100 removes the latching finger 102 from engagement with side R of the remote end 116 of the movable contact arm 50, and permits the contact arm 50 to return to its pre-stressed condition opening contacts 52 and 56, seen in Fig 7.

After tripping, the coil assembly 90 is de-energized so that spring 93 returns plunger 92 to its original extended position and banger 94 moves to its original position releasing latch member 100. At this time, the latch member 100 is in a lockout position where latch finger 102 inhibits movable contact 52 from engaging fixed contact 56, as seen in Fig. 10. As noted, one or both latching fingers 102 can act as an active inhibitor that prevents the contacts from touching. Alternatively, the natural bias of movable arms 50 and 70 can be used as a passive inhibitor that prevents the contacts from touching.

To reset the GFCI receptacle so that contacts 52 and 56 are closed and continuity in the phase conductive path is reestablished, the reset button 30 is depressed sufficiently to overcome the bias force of return spring 120 and move the latch member 100 in the direction of arrow A, seen in Fig. 8. While the reset button 30 is being depressed, latch finger 102 contacts side L of the movable contact arm 50 and continued depression of the reset button 30 forces the latch member to overcome the stress force exerted by the arm 50 causing the reset contact 104 on the arm 50 to close on reset contact 106. Closing the reset contacts activates the operation of the circuit interrupter by, for example simulating a fault, so that plunger 92 moves the banger 94 upwardly striking the latch member 100 which pivots the latch finger 102, while the latch member 100 continues to move in the direction of arrow A. As a result, the latch finger 102 is lifted over side L of the remote end 116 of the movable contact arm 50 onto side R of the remote end of the movable contact arm, as seen in Figs. 7 and 11. Contact arm 50 returns to its unstressed position, opening contacts 52 and 56 and contacts 62 and 66, so as to terminate the activation of the circuit interrupting portion, thereby de-energizing the coil assembly 90.

After the circuit interrupter operation is activated, the coil assembly 90 is de-energized so that so that plunger 92 returns to its original extended position, and banger 94 releases the latch member 100 so that the latch finger 102 is in a reset position, seen in Fig. 9. Release of the reset button causes the latching member 100 and movable

contact arm 50 to move in the direction of arrow B (seen in Fig. 9) until contact 52 electrically engages contact 56, as seen in Fig. 2.

As noted above, if opening and closing of electrical continuity in the neutral conductive path is desired, the above description for the phase conductive path is also applicable to the neutral conductive path.

In an alternative embodiment, the circuit interrupting devices may also include a trip portion that operates independently of the circuit interrupting portion so that in the event the circuit interrupting portion becomes non-operational the device can still be tripped. Preferably, the trip portion is manually activated and uses mechanical components to break one or more conductive paths. However, the trip portion may use electrical circuitry and/or electro-mechanical components to break either the phase or neutral conductive path or both paths.

For the purposes of the present application, the structure or mechanisms for this embodiment are also incorporated into a GFCI receptacle, seen in Figs. 13-20, suitable for installation in a single-gang junction box in a home. However, the mechanisms according to the present application can be included in any of the various devices in the family of resettable circuit interrupting devices.

FIG. 12A shows the schematic of a GFCI device using movable floating bridges that electrically connect the line terminals (34, 38) to the load terminals (36, 40) and user accessible terminals (also referred to as face terminals) (60,80). Movable arms 50 and 70 are now movable floating bridges in that they are not permanently electrically connected to any of the terminals. When the GFCI device is tripped (or is in a tripped condition) as shown in FIG. 12A, movable contacts 52, 62 and 65 of movable bridge 50 are electrically isolated from load contact 56, face contact 66 and line terminal contact 35. Similarly, movable contacts 72, 82 and 63 of movable bridge 70 are electrically isolated from load contact 76, face contact 86 and line terminal contact 39 when the GFCI device is tripped. There are no conductive paths connecting any terminal to any other terminal when the device is tripped or is in a tripped condition. Thus, there is complete electrical isolation between the terminals (face or user accessible, load and line). Bridge 50 electrically connects the phase terminals (line, face and load) terminals to each other and bridge 70 connects the neutral terminals (line, face and load) to each other. Bridge 50 has contacts 52, 62 and 65; bridge 70 has contact 72, 82 and 63. Line terminal 34

extends through the transformers DT and NT to contact 35 and line terminal 38 extends through the transformers DT and NT to contact 39. When the reset button 30 is depressed contact 104 makes with contact 106 causing a current imbalance which is detected by the DT transformer causing the IC to energize Q1 which energizes coil 90. The energized coil 90 causes movable floating bridges 50 and 70 to be engaged so that each such floating bridge individually connects a line, load and face terminals to each other. In particular, movable floating bridge 50 connects line terminal 34 to load terminal 36 and face terminal 60. Movable floating bridge 70 connects line terminal 38 to load terminal 40 and face terminal 80. It should be noted that the movable floating bridge can be implemented with contacts located at points occurring prior to the line terminals going through the DT and NT transformers; this is depicted in FIG. 12B. The line terminals, however are to be positioned so that a sensing device (e.g., a differential transformer) can detect a current imbalance between such terminals.

The floating movable bridge can be implemented using various conductor elements and contacts that interact and/or engage with each other when the GFCI device is tripped or when such a device is being reset. One particular implementation of the movable floating bridge arrangement is shown in FIG. 12C for a GFCI receptacle design disclosed in a Patent Application having the title "Circuit Interrupting Device And System Utilizing Electromechanical Reset" which was filed on October 22, 2003 and published on November 4, 2004 with Publication No. US 2004/0218316 the entirety of which is incorporated herein by reference. The Publication discloses an electromechanical reset mechanism whereby when the reset button is depressed (while the GFCI is tripped), reset contacts close a circuit that energizes a coil whose movable plunger which engages various mechanical linkages causing an actuator (such a lifter) to engage the movable bridges; see pp. 0049-0053. As discussed in paragraph 0053, the lifter engages the movable bridges causing the device to be reset. In FIG. 12C, the lifter 178 (preferably made from non-conducting material) operates in the same fashion as the one disclosed in the Publication; that is, it moves towards the line, load and face contacts causing the line, load and face terminals to be electrically connected to each other after the reset button has been depressed and is being released by a user. The floating bridges 167A and 167B are fixedly attached to lifter 178 and are made from electrically conducting material. The present invention also contemplates a floating bridge made



from non-conducting material but whose contacts are electrically connected to each other. When the device is tripped or is in a tripped condition, the movable floating bridge is electrically isolated from the line, face and load terminals. The electrical isolation means that there are no conductive paths electrically connecting any movable floating bridge to any of the terminals. When the device is tripped the load, face and line terminals are not only electrically isolated from the movable floating bridges, but they are electrically isolated from each other; that is, there are no conductive paths connecting any one terminal to any other terminal when the device is tripped.

As the user releases the depressed reset button, the spring bias of the reset button (not shown in FIG. 12C) causes the lifter 178 (preferably made from electrically non-conducting material) and the attached floating bridges (167A and 167B) to move in the direction shown by arrow 165 allowing the line contacts (137, 149), face contacts (168, 174) and load contacts (170, 172) of the floating bridges to electrically connect to the line (135, 151), load (158, 162) and face contacts (156, 160) respectively thus resetting the device. Face terminal 148 has face contact 156 and face terminal 146 (only a portion of which is shown in FIG. 12C) has face contact 160. The load terminals 132 and 154 have load contacts 158 and 162 respectively. The line terminals 134 and 153 extend through Differential and Ground Neutral transformers and terminate with contacts 135 and 151 respectively. The Differential and Ground Neutral transformers are used to sense any current imbalances between the line terminal conductors 134, 153. Thus, the line terminals are extended as conductors and positioned so as to be monitored by a sensing device (such as transformers) that sense current imbalances between the line terminals 134, 153. In the implementation shown in FIG. 12C, the line terminal conductors are routed through the Differential and Ground Neutral transformers which can then sense a current imbalance between the line terminal conductors. When the device is tripped, the lifter 178 moves in the direction opposite of that shown by arrow 165 disconnecting the terminals from each other and disconnecting the bridge from any of the terminals.

It should be noted that the electrical isolation between the terminals when the device is tripped and the electrical connection of the line load and face terminals when the device is reset can also be implemented without the use of a floating bridge. In particular, the line terminal contact, face terminal contact and load terminal contact can

be positioned in stacked fashion with respect to each other. For example, the load terminal contact can be positioned directly above the face terminal contact and the line terminal contact can be positioned directly below the face terminal contact. As the user releases the depressed reset button, the spring bias of the reset button causes an actuator  
5 (in the example given--- lifter 178) to move to cause the line contact to electrically connect to the face contact and the face contact electrically connect to the load contact thus resetting the device; this is shown in FIGS. 12D and 12E where a side views of the contacts electrically isolated with each other and the contacts electrically connected to each other using the lifter 178 are shown. In particular for face terminal 148, load  
10 terminal 132 and line terminal 134, the device in the tripped condition is shown in FIG. 12D and the device in the reset position is shown in FIG. 12E. Thus, the actuator (e.g., lifter 178) is positioned so that it can engage at least one of the terminals or terminal contacts to cause said terminals or terminal contact to electrically connect to each other. When the device is tripped lifter 178 moves in a direction opposite that shown by arrow  
15 165 to cause the terminals to be electrically disconnected from each other; that is the terminals have a spring bias so that they return to their particular positions as shown in FIG. 12D.

Referring back to FIG. 12C, the floating bridges 167A and 167B can be permanently attached and be integral with the load terminals or the face terminals or the  
20 line terminals. For example, bridge 167A can be permanently connected to and integral with load terminal 132 and positioned to be engaged by lifter 178 (preferably electrically non-conducting) such that when the lifter 178 moves in the direction of arrow 165, the load terminal electrically connects to the face and line terminals. Similarly, bridge 167A can be permanently connected to and integral with face terminal 148 such that when  
25 lifter 178 moves in the direction of arrow 165, the face terminal electrically connects to the load and the line terminals; the same arrangement can be done for bridge 167B, load terminal 145 and face terminal 146.

Turning now to Fig. 13, the GFCI receptacle 200 according to this embodiment is similar to the GFCI receptacle described in Figs. 1-12. Similar to Fig. 1, the GFCI  
30 receptacle 200 has a housing 12 consisting of a relatively central body 14 to which a face or cover portion 16 and a rear portion 18 are, preferably, removably secured.

A trip actuator 202, preferably a button, which is part of the trip portion to be described in more detail below, extends through opening 28 in the face portion 16 of the housing 12. The trip actuator is used, in this exemplary embodiment, to mechanically trip the GFCI receptacle, i.e., break electrical continuity in one or more of the conductive paths, independent of the operation of the circuit interrupting portion.

A reset actuator 30, preferably a button, which is part of the reset portion, extends through opening 32 in the face portion 16 of the housing 12. The reset button is used to activate the reset operation, which re-establishes electrical continuity in the open conductive paths, i.e., resets the device, if the circuit interrupting portion is operational.

As in the above embodiment, electrical connections to existing household electrical wiring are made via binding screws 34 and 36, where screw 34 is an input (or line) phase connection, and screw 36 is an output (or load) phase connection. It should be noted that two additional binding screws 38 and 40 (seen in Fig. 3) are located on the opposite side of the receptacle 200. These additional binding screws provide line and load neutral connections, respectively. A more detailed description of a GFCI receptacle is provided in U.S. Patent 4,595,894, which is incorporated herein in its entirety by reference.

Referring to Figs. 4-6, 14 and 17, the conductive paths in this embodiment are substantially the same as those described above. The conductive path between the line phase connection 34 and the load phase connection 36 includes, contact arm 50 which is movable between stressed and unstressed positions, movable contact 52 mounted to the contact arm 50, contact arm 54 secured to or monolithically formed into the load phase connection 36 and fixed contact 56 mounted to the contact arm 54 (seen in Figs. 4, 5 and 17). The user accessible load phase connection for this embodiment includes terminal assembly 58 having two binding terminals 60 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line phase connection 34 and the user accessible load phase connection includes, contact arm 50, movable contact 62 mounted to contact arm 50, contact arm 64 secured to or monolithically formed into terminal assembly 58, and fixed contact 66 mounted to contact arm 64. These conductive paths are collectively called the phase conductive path.

Similarly, the conductive path between the line neutral connection 38 and the load neutral connection 40 includes, contact arm 70 which is movable between stressed and unstressed positions, movable contact 72 mounted to contact arm 70, contact arm 74 secured to or monolithically formed into load neutral connection 40, and fixed contact 76 mounted to the contact arm 74 (seen in Figs. 4, 6 and 17). The user accessible load neutral connection for this embodiment includes terminal assembly 78 having two binding terminals 80 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line neutral connection 38 and the user accessible load neutral connection includes, contact arm 70, movable contact 82 mounted to the contact arm 70, contact arm 84 secured to or monolithically formed into terminal assembly 78, and fixed contact 86 mounted to contact arm 84. These conductive paths are collectively called the neutral conductive path.

There is also shown in Fig. 14, mechanical components used during circuit interrupting and reset operations according to this embodiment of the present application. Although these components shown in the drawings are electro-mechanical in nature, the present application also contemplates using semiconductor type circuit interrupting and reset components, as well as other mechanisms capable of making and breaking electrical continuity.

The circuit interrupting device according to this embodiment incorporates an independent trip portion into the circuit interrupting device of Figs. 1-12. Therefore, a description of the circuit interrupting, reset and reset lockout portions are omitted.

Referring to Figs. 14 -16 an exemplary embodiment of the trip portion according to the present application includes a trip actuator 202, preferably a button, that is movable between a set position, where contacts 52 and 56 are permitted to close or make contact, as seen in Fig. 14, and a trip position where contacts 52 and 56 are caused to open, as seen in Fig. 15. Spring 204 normally biases trip actuator 202 toward the set position. The trip portion also includes a trip arm 206 that extends from the trip actuator 202 so that a surface 208 of the trip arm 206 moves into contact with the movable latching member 100, when the trip button is moved toward the trip position. When the trip actuator 202 is in the set position, surface 208 of trip arm 202 can be in contact with or close proximity to the movable latching member 100, as seen in Fig. 14.

In operation, upon depression of the trip actuator 202, the trip actuator pivots about point T of pivot arm 210 (seen in Fig. 15) extending from strap 24 so that the surface 208 of the trip arm 206 can contact the movable latching member 100. As the trip actuator 202 is moved toward the trip position, trip arm 206 also enters the path of movement of the finger 110 associated with reset button 30 thus blocking the finger 102 from further movement in the direction of arrow A (seen in Fig. 15). By blocking the movement of the finger 110, the trip arm 206 inhibits the activation of the reset operation and, thus, inhibits simultaneous activation of the trip and reset operations. Further depression of the trip actuator 202 causes the movable latching member 100 to pivot about point T in the direction of arrow C (seen in Fig. 15). Pivotal movement of the latching member 100 causes latching finger 102 of latching arm 100 to move out of contact with the movable contact arm 50 so that the arm 50 returns to its unstressed condition, and the conductive path is broken. Resetting of the device is achieved as described above. An exemplary embodiment of the circuitry used to sense faults and reset the conductive paths, is shown in Fig. 18.

As noted above, if opening and closing of electrical continuity in the neutral conductive path is desired, the above description for the phase conductive path is also applicable to the neutral conductive path.

An alternative embodiment of the trip portion will be described with reference to Figs. 19 and 20. In this embodiment, the trip portion includes a trip actuator 202 that at is movable between a set position, where contacts 52 and 56 are permitted to close or make contact, as seen in Fig. 19, and a trip position where contacts 52 and 56 are caused to open, as seen in Fig. 20. Spring 220 normally biases trip actuator 202 toward the set position. The trip portion also includes a trip arm 224 that extends from the trip actuator 202 so that a distal end 226 of the trip arm is in movable contact with the movable latching member 100. As noted above, the movable latching member 100 is, in this embodiment, common to the trip, circuit interrupting, reset and reset lockout portions and is used to make, break or lockout the electrical connections in the phase and/or neutral conductive paths.

In this embodiment, the movable latching member 100 includes a ramped portion 100a which facilitates opening and closing of electrical contacts 52 and 56 when the trip actuator 202 is moved between the set and trip positions, respectively. To illustrate,

when the trip actuator 202 is in the set position, distal end 226 of trip arm 224 contacts the upper side of the ramped portion 100a, seen in Fig. 19. When the trip actuator 202 is depressed, the distal end 226 of the trip arm 224 moves along the ramp and pivots the latching member 60 about point P in the direction of arrow C causing latching finger 102  
5 of the latching member 100 to move out of contact with the movable contact arm 50 so that the arm 50 returns to its unstressed condition, and the conductive path is broken. Resetting of the device is achieved as described above.

#### Industrial Applicability

The circuit interrupting device described herein is applicable to electrical  
10 systems, as shown in the exemplary block diagram of Fig. 21. The system 240 includes a source of power 242, such as ac power in a home, at least one circuit interrupting device, e.g., circuit interrupting device 10 or 200, electrically connected to the power source, and one or more loads 244 connected to the circuit interrupting device. As an  
15 example of one such system, ac power supplied to single gang junction box in a home may be connected to a GFCI receptacle having one of the above described reverse wiring fault protection, independent trip or reset lockout features, or any combination of these features may be combined into the circuit interrupting device. Household appliances that are then plugged into the receptacle become the load or loads of the system.

As noted, although the components used during circuit interrupting and device  
20 reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

While there have been shown and described and pointed out the fundamental  
25 features of the invention, it will be understood that various omissions and substitutions and changes of the form and details of the device described and illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention.



1. A circuit interrupting device comprising:

a first electrical conductor capable of being electrically connected to a source of electricity;

5 a second electrical conductor capable of conducting electrical current to a load when electrically connected to said first electrical conductor;

a third electrical conductor capable of being electrically connected to user accessible plugs and/or receptacles where the first, second and third electrical conductors are electrically isolated from each other;

10 at least one movable floating bridge electrically isolated from said first, second and third electrical conductors, said at least one movable bridge capable of electrically connecting the first, second and third electrical conductors to each other;

a circuit interrupting portion configured to cause electrical discontinuity between said first, second and third electrical conductors upon the occurrence of a predetermined condition; and

15 a reset portion configured to reestablish electrical continuity between the first, second and third electrical conductors after said predetermined condition occurs.

2. The circuit interrupting device of claim 1 where the at least one movable floating bridge is positioned so as to electrically connect the first electrical conductor to the  
20 second and third electrical conductors when the device is reset and the at least one movable bridge is positioned so as to disconnect electrically the first electrical conductor from the second and third electrical conductors and be electrically isolated from the first, second and third electrical conductors when the device is in a trip condition.

25 3. The circuit interrupting device of claim 1 where the condition comprises a ground fault, an arc fault, an appliance leakage fault, an equipment leakage fault or an immersion detection fault.

30 4. The circuit interrupting device of claim 1 further comprising a trip portion that is configured to cause electrical discontinuity between the first, second and third electrical conductors.

5. The circuit interrupting device of claim 1 further comprising a sensing circuit for detecting an occurrence of a predetermined condition.

5 6. The circuit interrupting device of claim 1 where the circuit interrupting portion comprises a coil and plunger assembly at least one movable floating bridge and a sensing circuit used to detect a predetermined condition.

7. The circuit interrupting device of claim 1 where the at least one movable floating bridge has:  
10 three contacts attached thereto where such contacts are positioned so as to be electrically connected to corresponding three contacts one of which is electrically connected to the first electrical conductor, the second of which is electrically connected to the second electrical conductor and the third of which is connected to the third electrical conductor.

15 8. The circuit interrupting device of claim 1 where the first electrical conductor comprises a contact connected to electric conducting material.

9. The circuit interrupting device of claim 1 where the second electrical conductor  
20 comprises a contact connected to electric conducting material.

10. The circuit interrupting device of claim 1 where the third electrical conductor comprises a contact connected to an electrically conducting frame forming a receptacle that is accessible to a user of the device.

25 11. The circuit interrupting device of claim 1 where the first electrical conductor is positioned so that it can be monitored by a sensing device.

12. A circuit interrupting device comprising:  
30 a first electrical conductor capable of being electrically connected to a source of electricity;



a second electrical conductor capable of conducting electrical current to a load when electrically connected to said first electrical conductor;

a third electrical conductor capable of being electrically connected to user accessible plugs and/or receptacles where the first, second and third electrical conductors are electrically isolated from each other and the first, second and third electrical conductors being positioned with respect to each other so that they can be engaged to electrically connect to each other;

an actuator positioned so that it can engage at least one of the first, second and third electrical conductors to cause the first, second and third electrical conductors to electrically connect to each other;

a circuit interrupting portion configured to cause electrical discontinuity between said first, second and third electrical conductors upon the occurrence of a predetermined condition; and

a reset portion configured to reestablish electrical continuity between the first, second and third electrical conductors after said predetermined condition occurs.

13. The circuit interrupting device of claim 12 where the actuator is positioned so as to cause the first, second and third electrical conductors to electrically connect to each other when the device is reset and the actuator is positioned so as to cause the first, second and third electrical conductors to be disconnected from each other when the device is in a trip condition.

14. The circuit interrupting device of claim 12 where the condition comprises a ground fault, an arc fault, an appliance leakage fault, an equipment leakage fault or an immersion detection fault.

15. The circuit interrupting device of claim 12 further comprising a trip portion that is configured to cause electrical discontinuity between the first, second and third electrical conductors.

16. The circuit interrupting device of claim 12 further comprising a sensing circuit for detecting an occurrence of a predetermined condition.

17. The circuit interrupting device of claim 1 where the circuit interrupting portion comprises a coil and plunger assembly at least one actuator and a sensing circuit used to detect a predetermined condition.

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18. The circuit interrupting device of claim 12 where the first electrical conductor comprises a contact connected to electric conducting material.

10 19. The circuit interrupting device of claim 12 where the second electrical conductor comprises a contact connected to electric conducting material.

20. The circuit interrupting device of claim 12 where the third electrical conductor comprises a contact connected to an electrically conducting frame forming a receptacle that is accessible to a user of the device.

15

21. The circuit interrupting device of claim 12 where the first electrical conductor is positioned so that it can be monitored by a sensing device.

22. A circuit interrupting device comprising:

20 a first pair of terminals capable of being electrically connected to a source of electricity;

a second pair of terminals capable of conducting electrical current to a load when electrically connected to said first pair of terminals;

25 a third pair of terminals capable of being electrically connected to user accessible plugs and/or receptacles where the first, second and third pair of terminals are electrically isolated from each other;

at least one movable bridge electrically isolated from said first, second and third pair of terminals and capable of electrically connecting the first, second and third pairs of terminals to each other;

30 a circuit interrupting portion configured to cause electrical discontinuity between said first, second and third pairs of terminals upon the occurrence of a predetermined condition;

a reset portion configured to reestablish electrical continuity between the first, second and third pairs of terminals after said predetermined condition occurs.

23. The circuit interrupting device of claim 22 where the at least one movable bridge is positioned so as to electrically connect the first pair of terminals to the second and third pairs of terminals when the device is reset and the movable bridge is positioned so as to disconnect electrically the first pair of terminals from the second and third pairs of terminals when the device is in a trip condition.

24. The circuit interrupting device of claim 22 where the condition comprises a ground fault, an arc fault, an appliance leakage fault, equipment leakage fault or an immersion detection fault.

25. The circuit interrupting device of claim 22 further comprising a trip portion that is configured to cause electrical discontinuity between the first, second and third pairs of terminals.

26. The circuit interrupting device of claim 22 further comprising a sensing circuit for detecting an occurrence of a predetermined condition.

27. The circuit interrupting device of claim 22 where the circuit interrupting device portion comprises a coil and plunger assembly, at least one movable bridge and a sensing circuit used to detect a predetermined condition.

28. The circuit interrupting device of claim 22 where the at least one movable floating bridge has:

three pairs of contacts attached thereto and where such first pair is positioned so as to make electrical contact with a corresponding pair of line terminal contacts;

a second pair of contacts positioned so as to make electrical contact with a corresponding pair of load terminal contacts; and

a third pair of contacts positioned so as to make electrical contact with a corresponding pair of user accessible terminal contacts.

29. The circuit interrupting device of claim 22 where the first pair of terminals comprises a pair of contacts connected to a pair of electrical conductors.

5 30. The circuit interrupting device of claim 22 where the second pair of terminals comprises a pair of contacts connected to a pair of electrical conductors.

31. The circuit interrupting device of claim 22 where the third pair of terminals comprises a pair of contacts connected to a pair of electrically conducting frames  
10 forming a pair of receptacles that is accessible to a user of the device.

32. The circuit interrupting device of claim 22 where the first pair of terminals is positioned so that it can be monitored by a sensing device.

15 33. A circuit interrupting device comprising:

a first pair of terminals capable of being electrically connected to a source of electricity;

a second pair of terminals capable of conducting electrical current to a load when electrically connected to said first pair of terminals;

20 a third pair of terminals capable of being electrically connected to user accessible plugs and/or receptacles where the first, second and third pair of terminals are electrically isolated from each other;

an actuator positioned so that it can engage at least one of the first, second and third pair of terminals to electrically connect to each other;

25 a circuit interrupting portion configured to cause electrical discontinuity between said first, second and third pairs of terminals upon the occurrence of a predetermined condition;

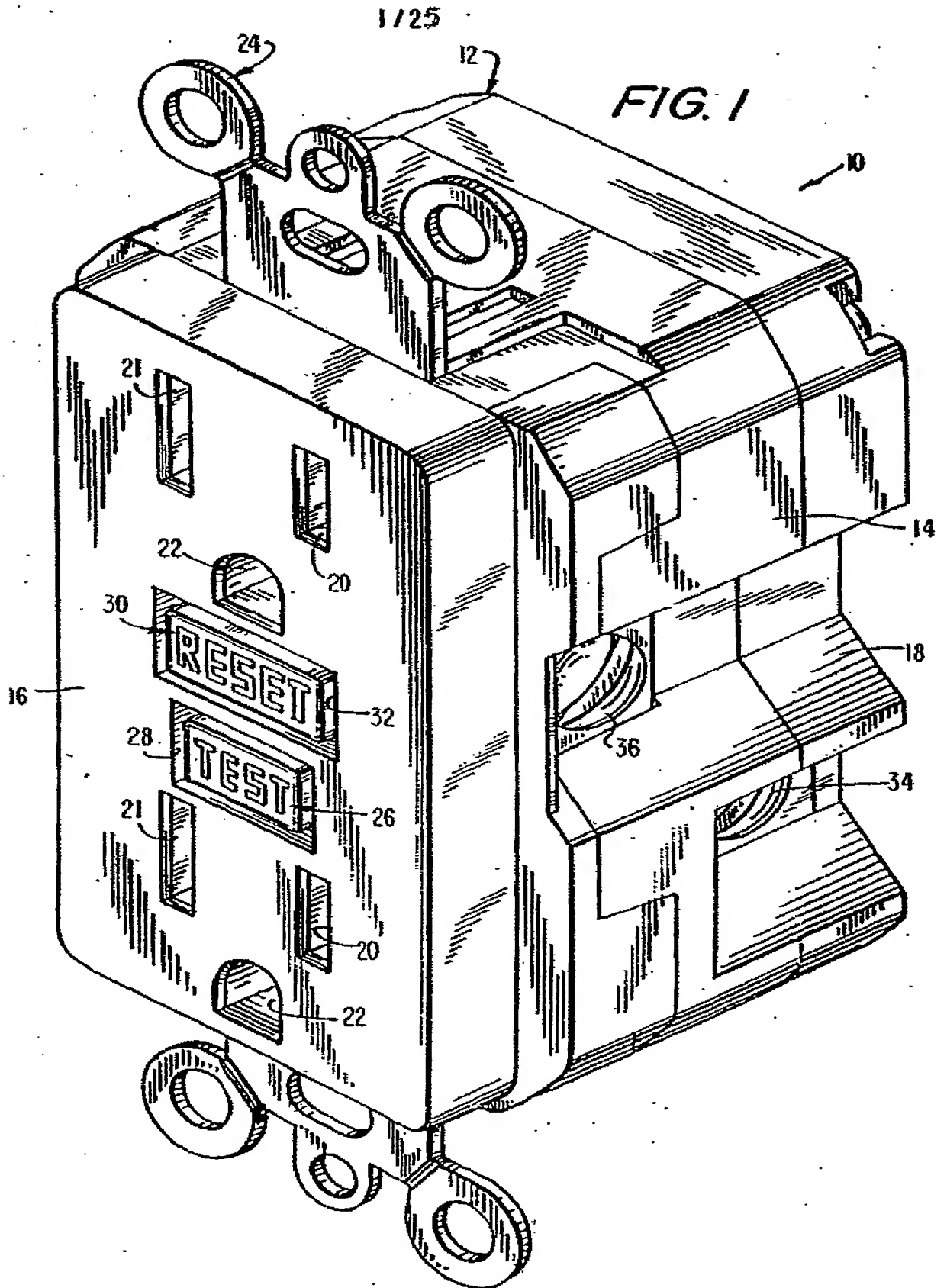
a reset portion configured to reestablish electrical continuity between the first, second and third pairs of terminals after said predetermined condition occurs.

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34. The circuit interrupting device of claim 33 where the actuator is positioned so as to cause the first, second and third pair of terminals to electrically connect to each other

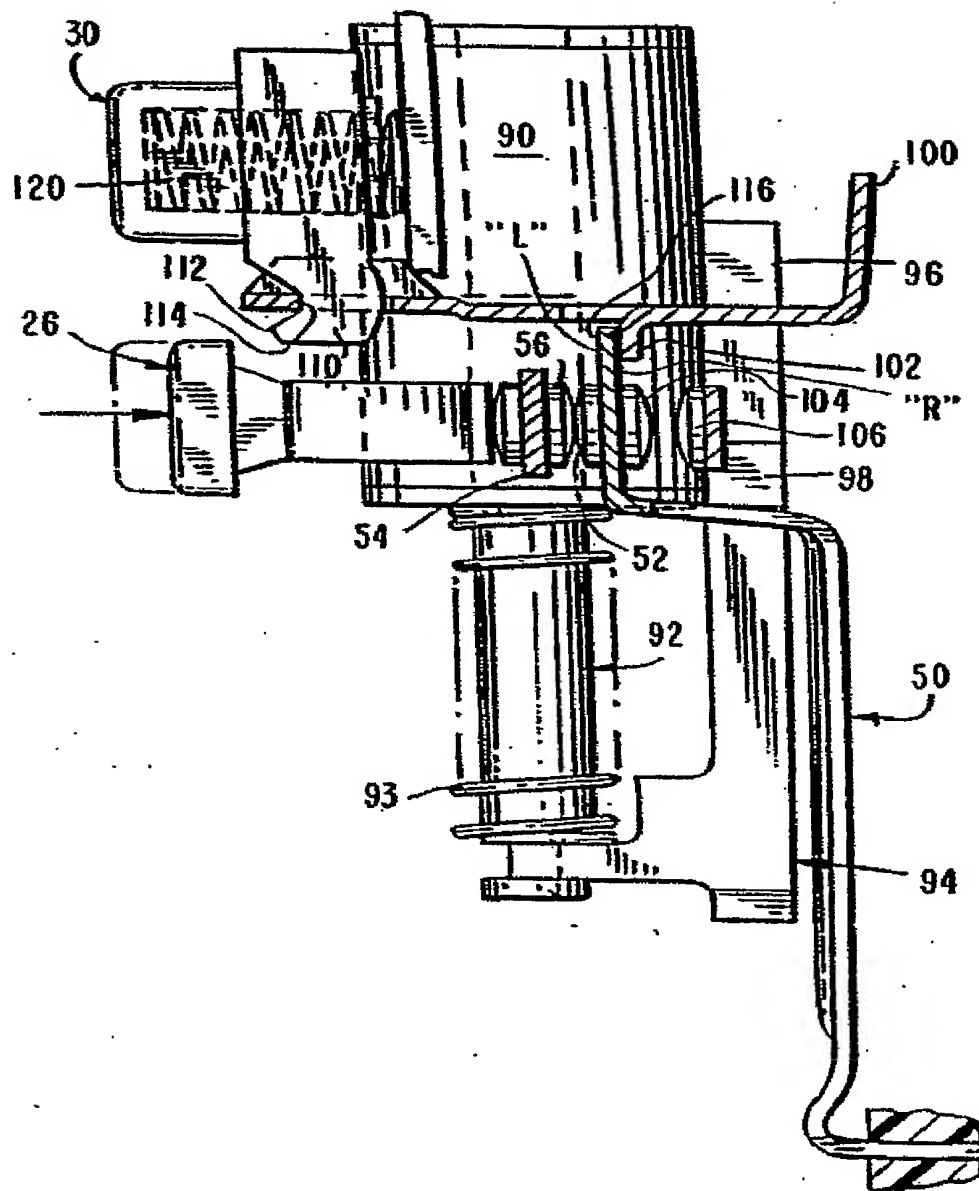
when the device is reset and the actuator is positioned so as to cause the first, second and third pair of terminals to be disconnected from each other when the device is in a trip condition.

- 5 35. The circuit interrupting device of claim 33 where the condition comprises a ground fault, an arc fault, an appliance leakage fault, equipment leakage fault or an immersion detection fault.
- 10 36. The circuit interrupting device of claim 33 further comprising a trip portion that is configured to cause electrical discontinuity between the first, second and third pairs of terminals.
- 15 37. The circuit interrupting device of claim 33 further comprising a sensing circuit for detecting an occurrence of a predetermined condition.
38. The circuit interrupting device of claim 33 where the circuit interrupting device portion comprises a coil and plunger assembly, at least one actuator and a sensing circuit used to detect a predetermined condition.
- 20 39. The circuit interrupting device of claim 33 where the first pair of terminals comprises a pair of contacts connected to a pair of electrical conductors.
40. The circuit interrupting device of claim 33 where the second pair of terminals comprises a pair of contacts connected to a pair of electrical conductors.
- 25 41. The circuit interrupting device of claim 33 where the third pair of terminals comprises a pair of contacts connected to a pair of electrically conducting frames forming a pair of receptacles that is accessible to a user of the device.
- 30 42. The circuit interrupting device of claim 33 where the first pair of terminals is positioned so that it can be monitored by a sensing device.



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FIG. 2



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FIG. 3

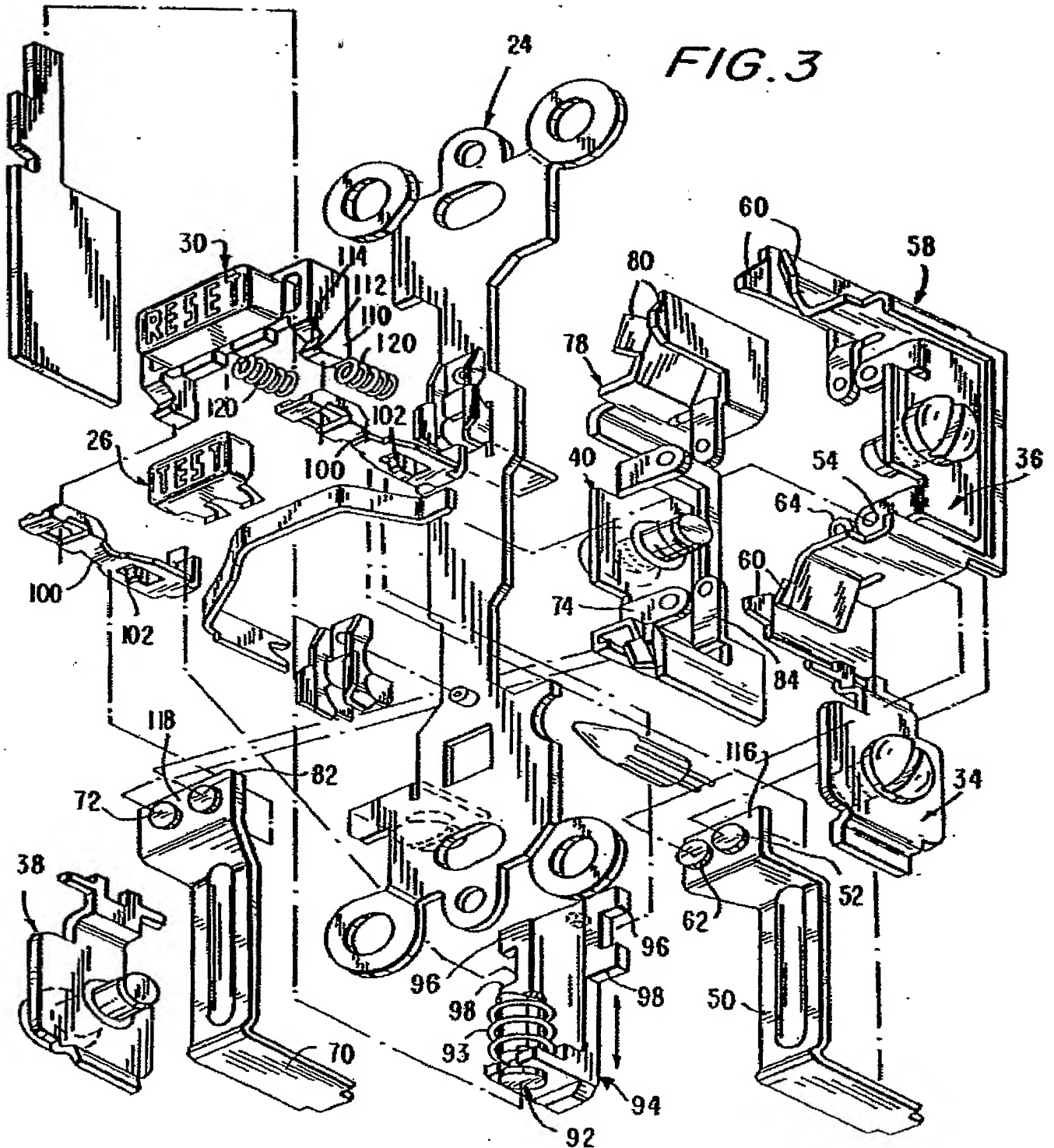
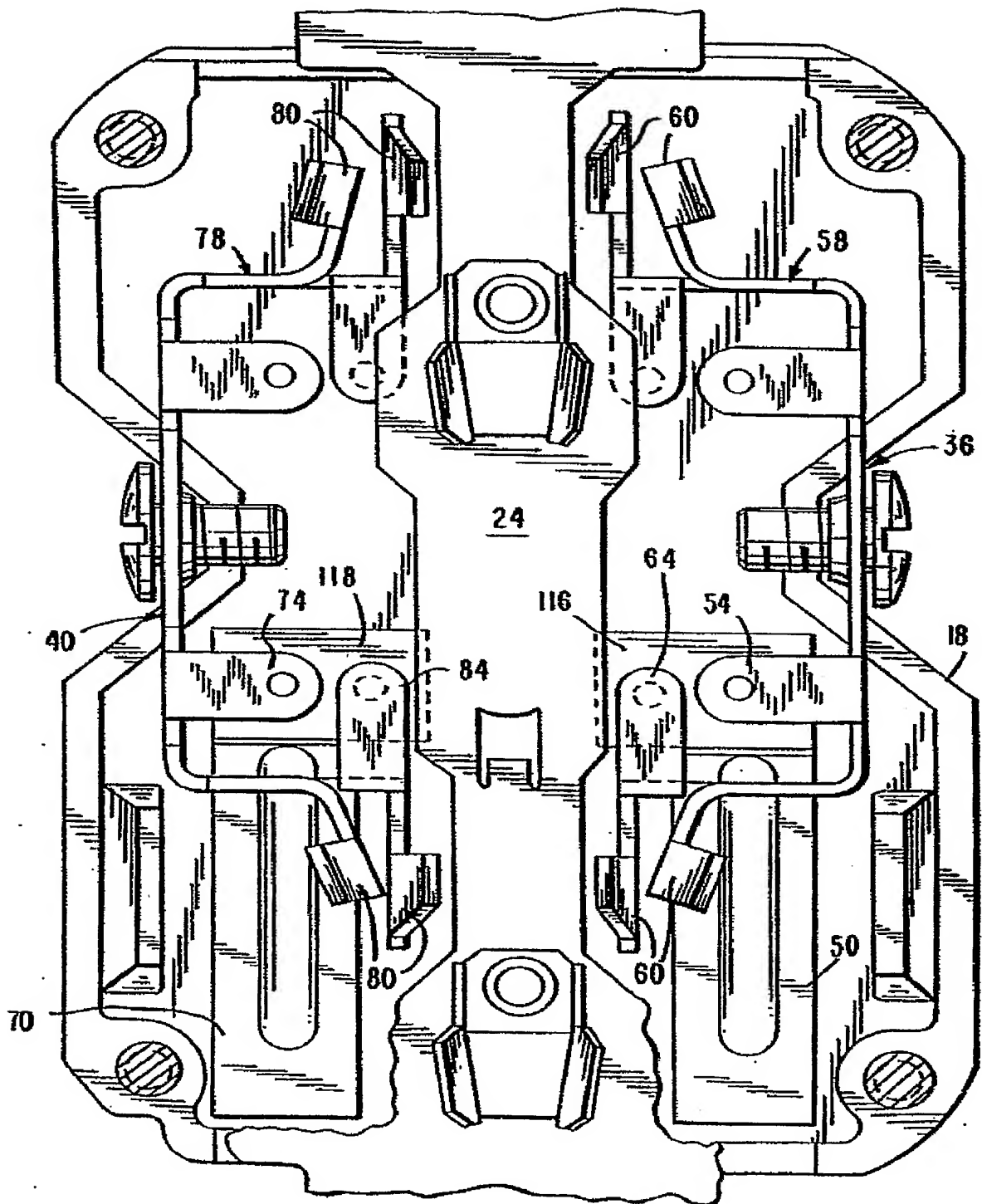




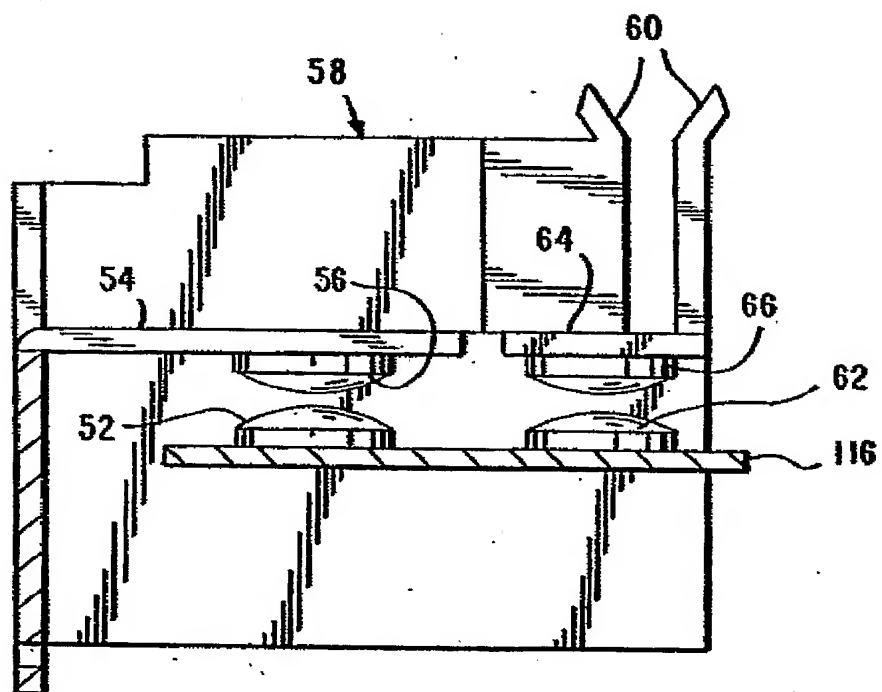
FIG. 4

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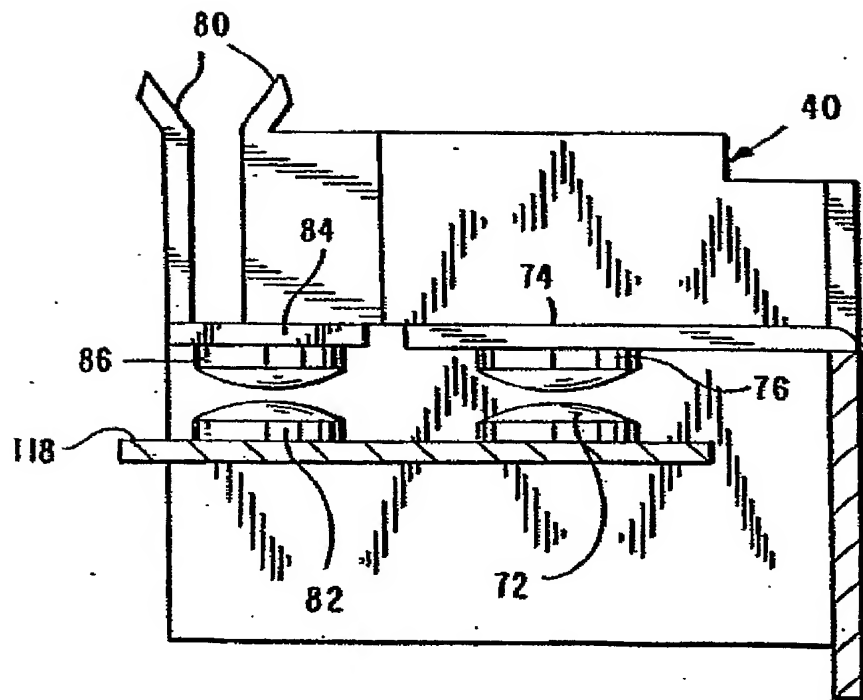
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FIG. 5



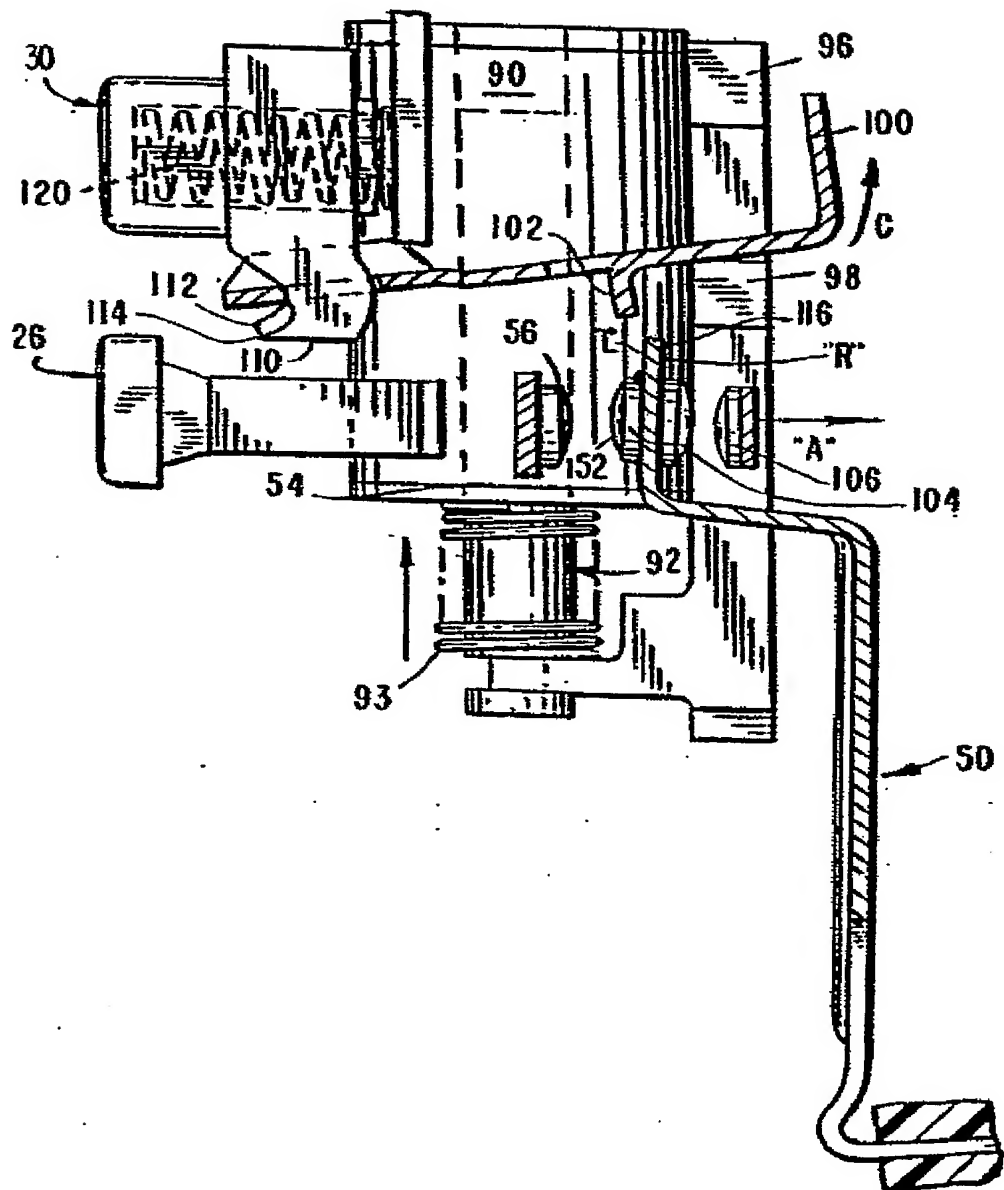
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**FIG. 6**



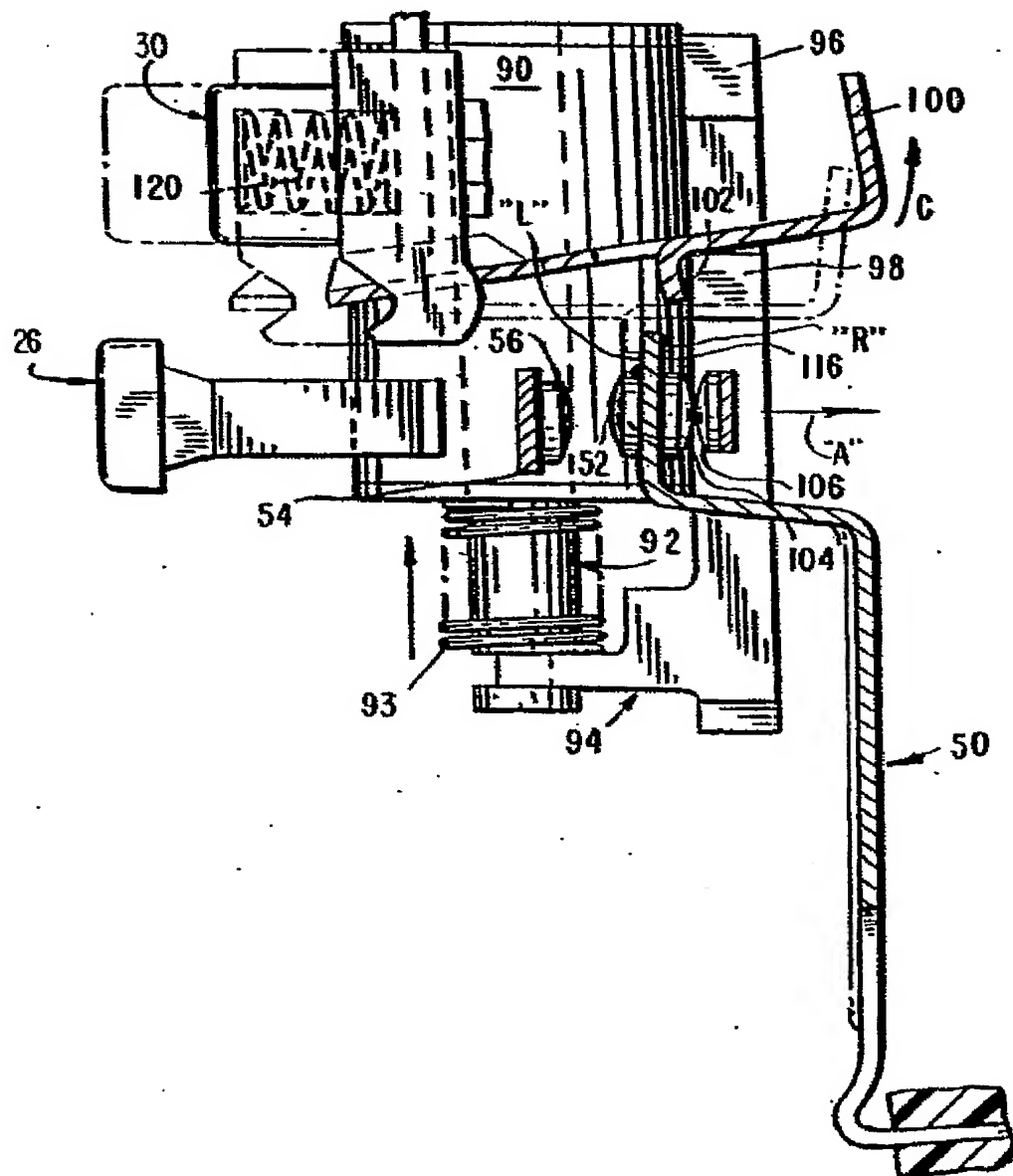
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FIG. 7

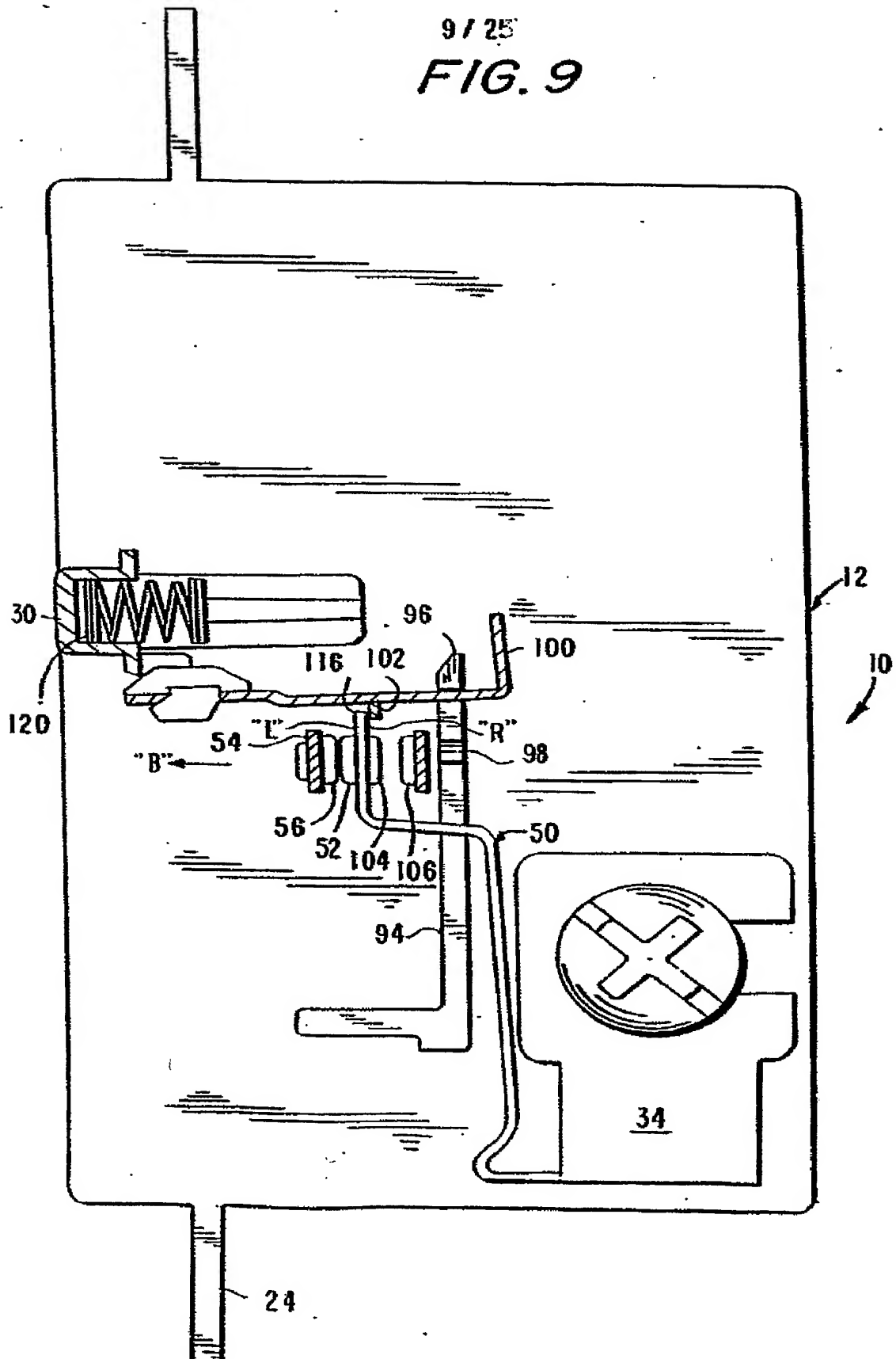


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FIG. 8

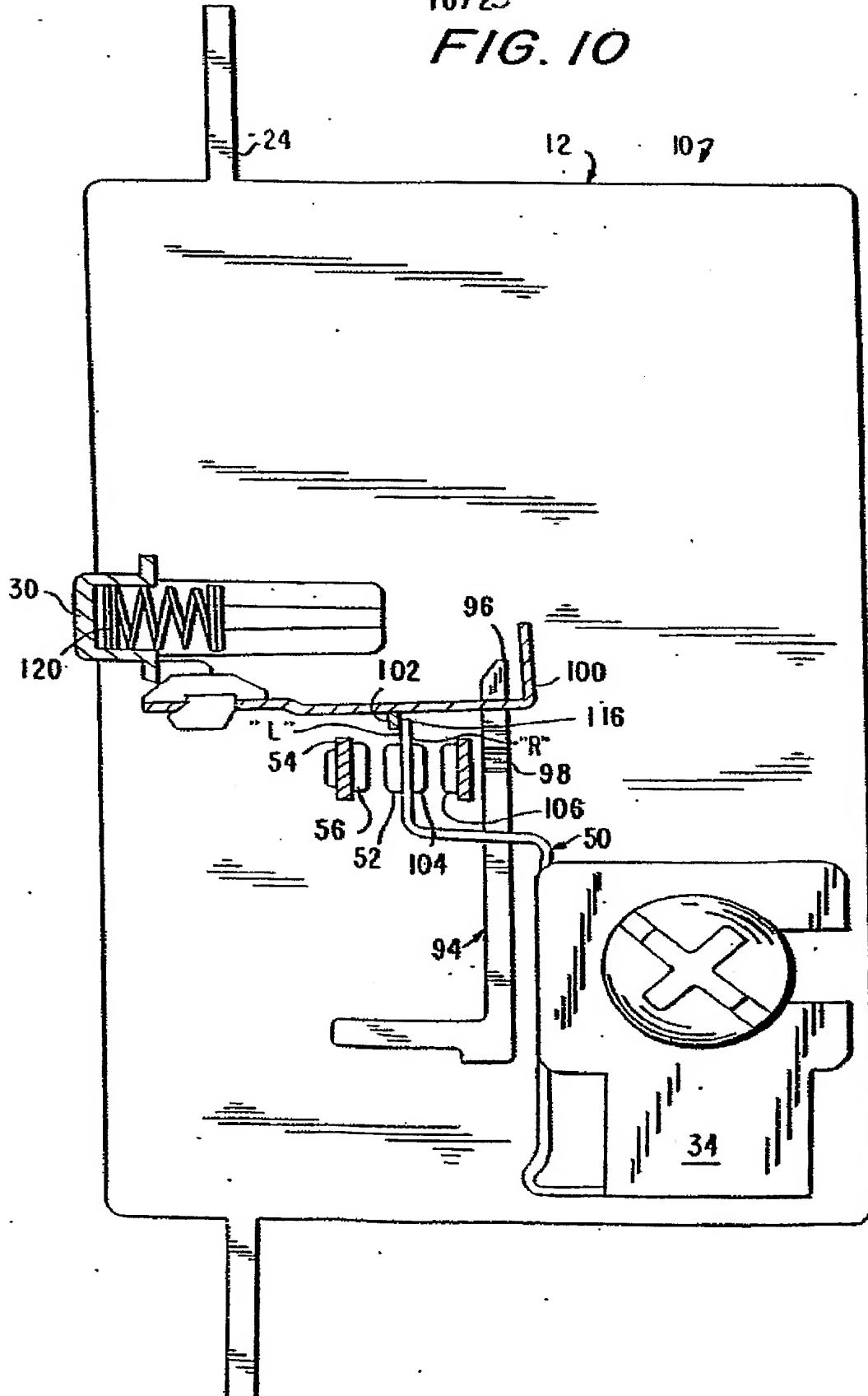


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FIG. 9



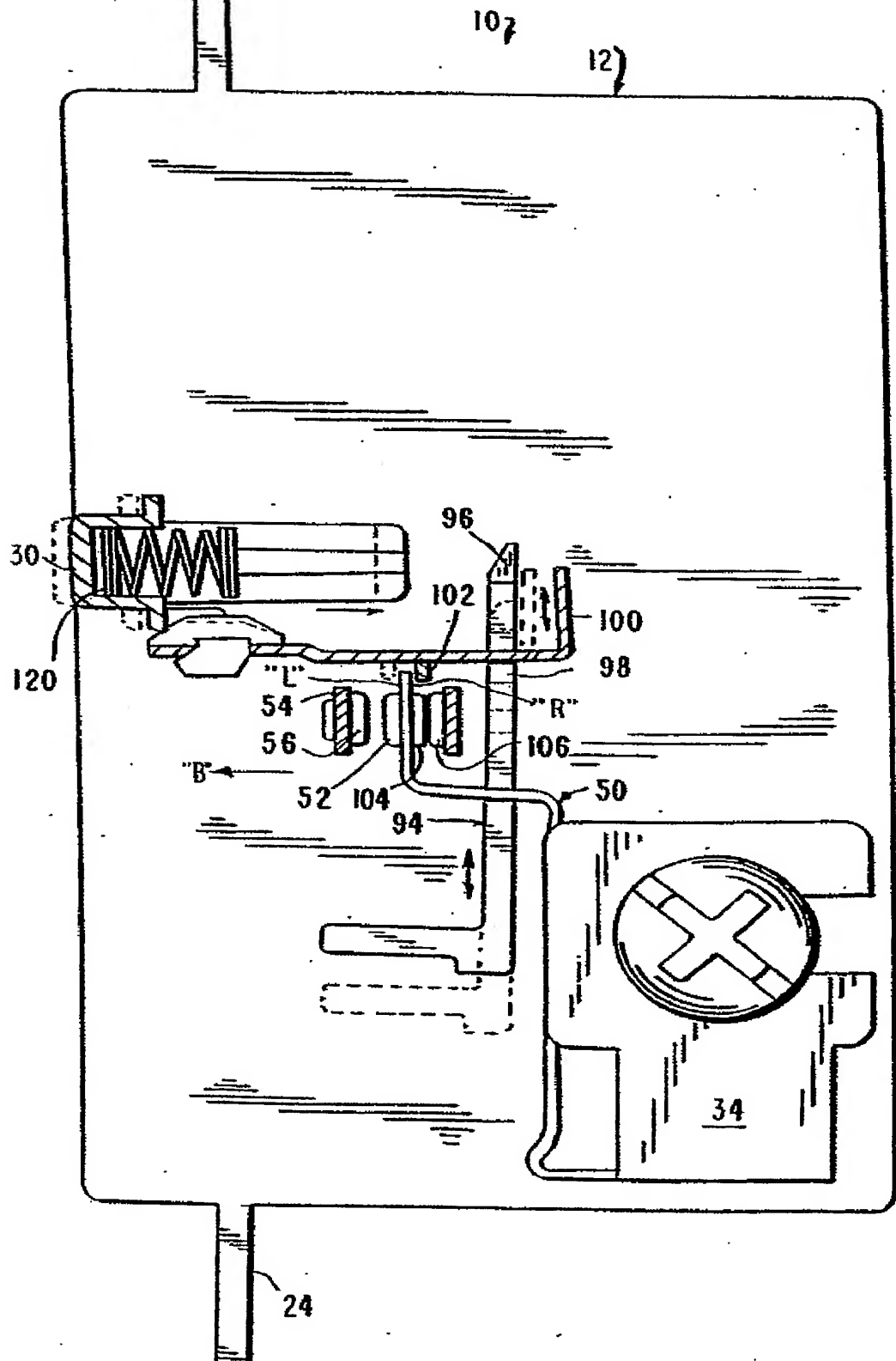
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FIG. 10



117.25

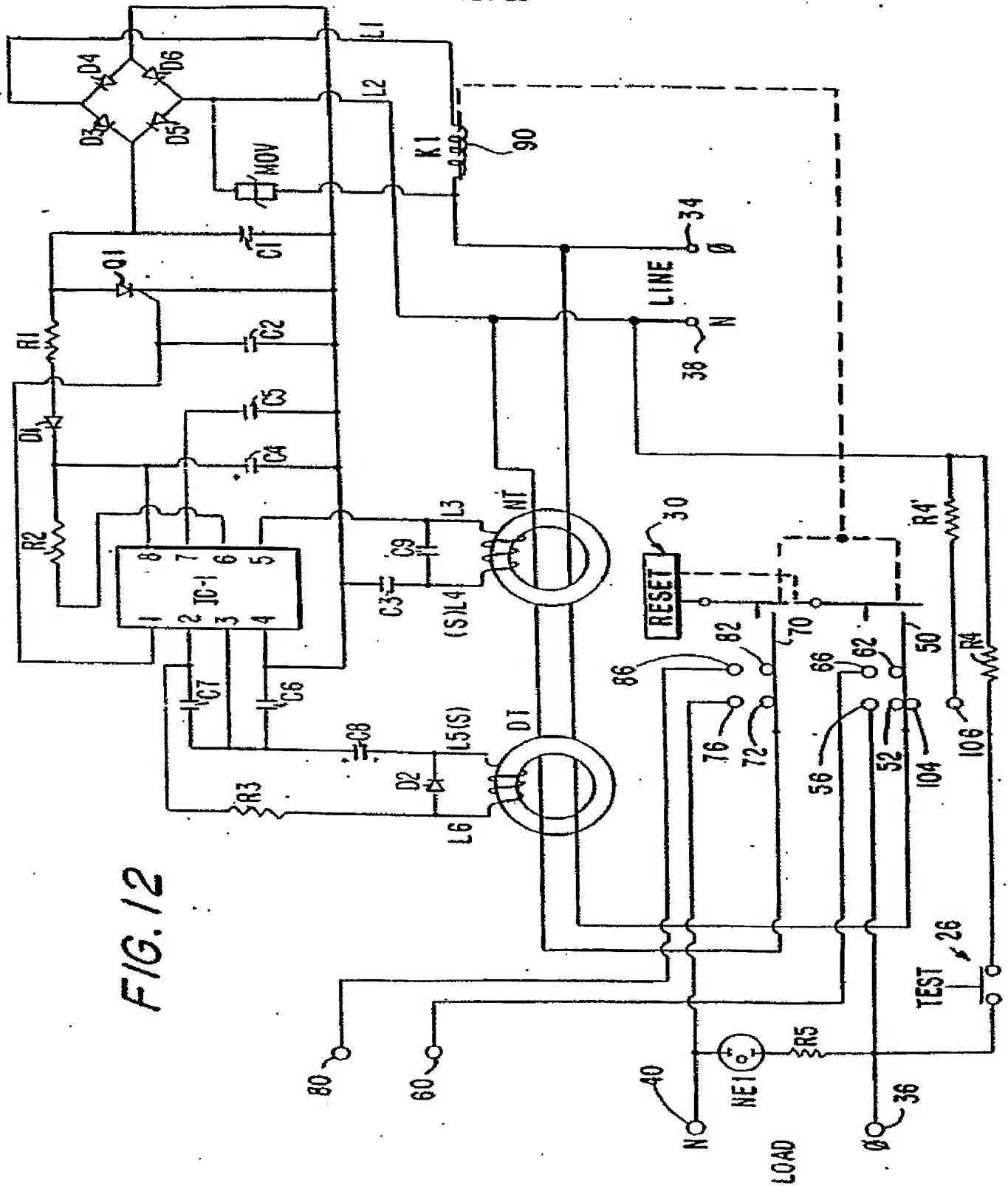
**FIG. 11**





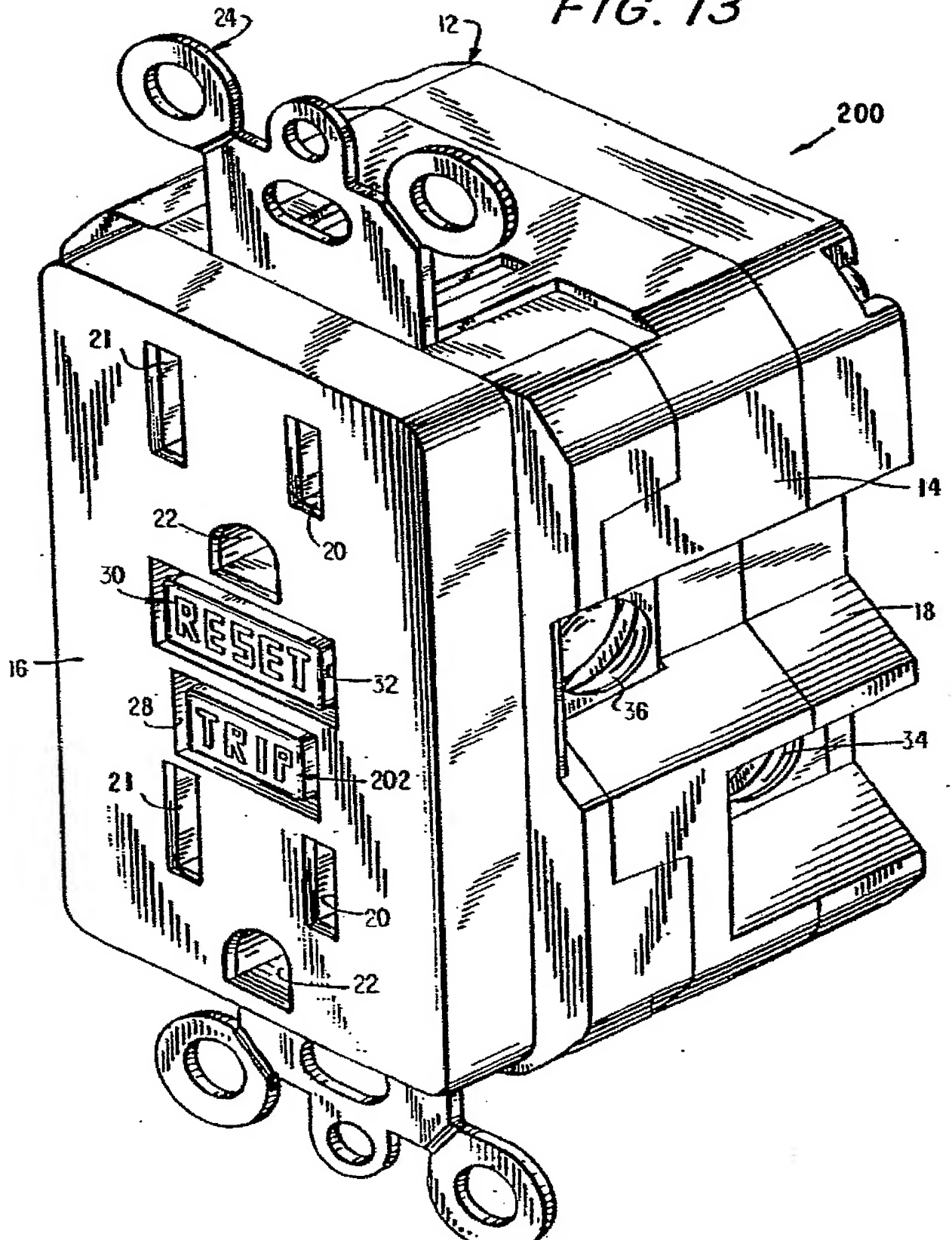
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FIG. 12



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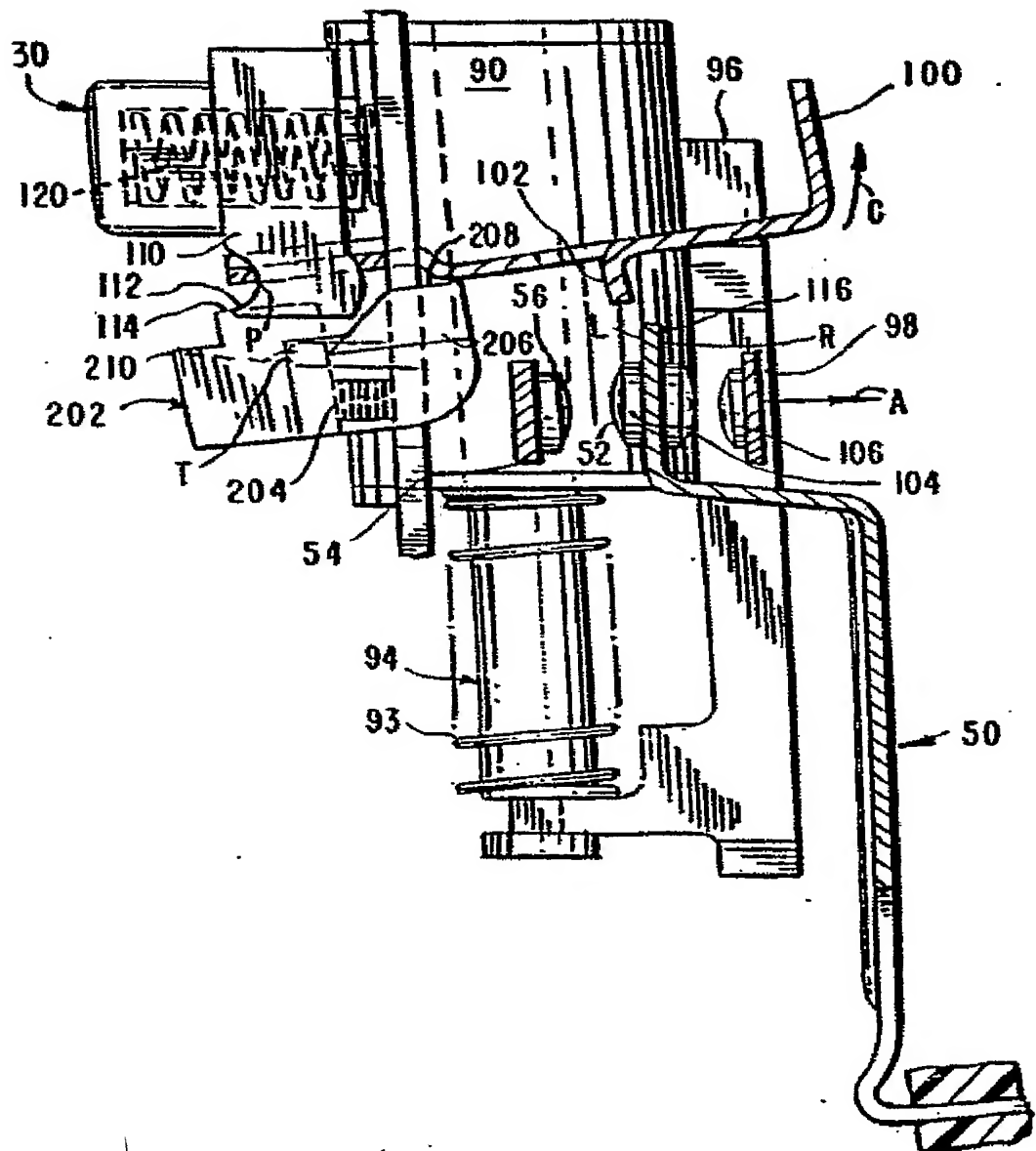
FIG. 13





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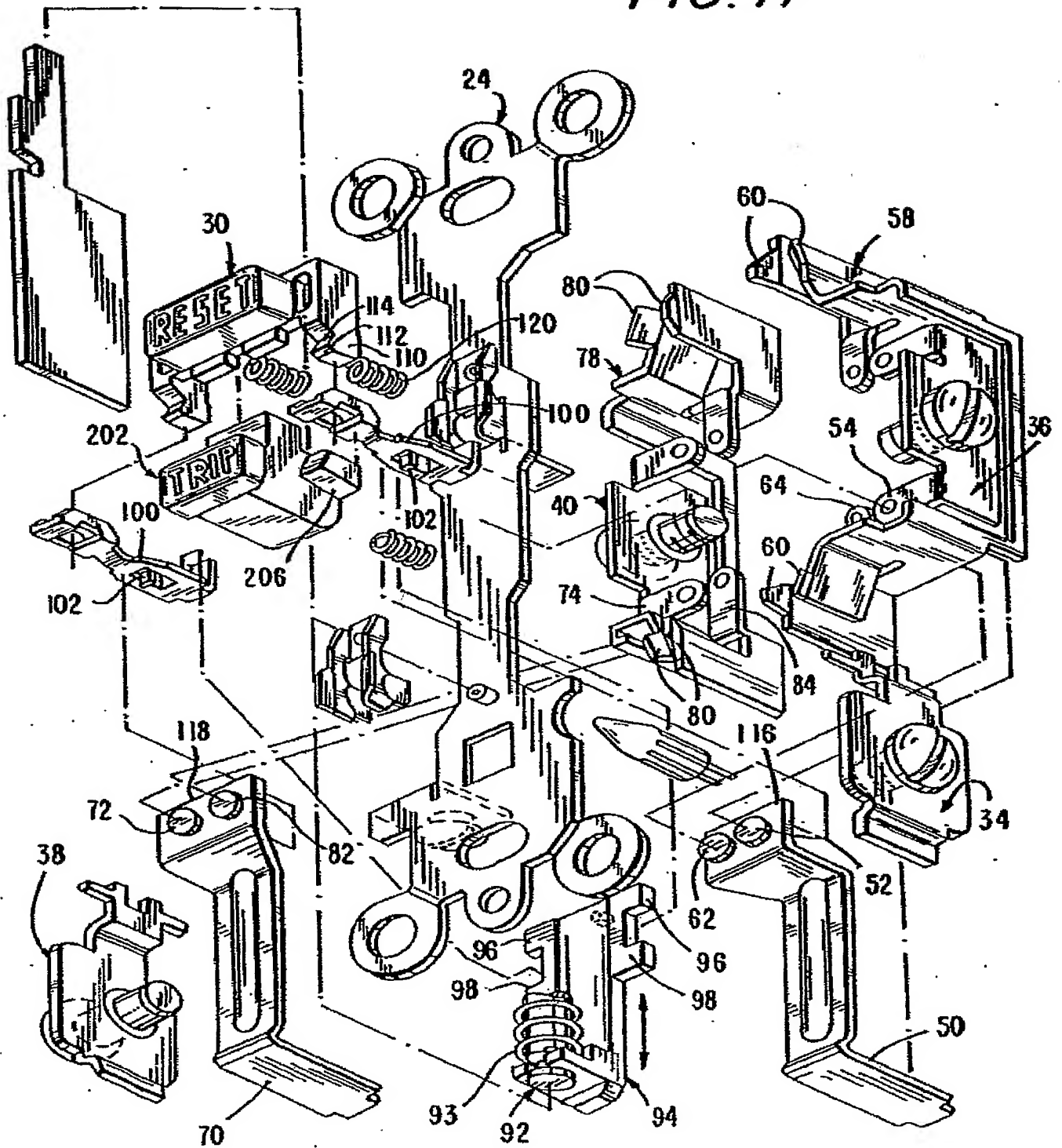
FIG. 15





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FIG. 17



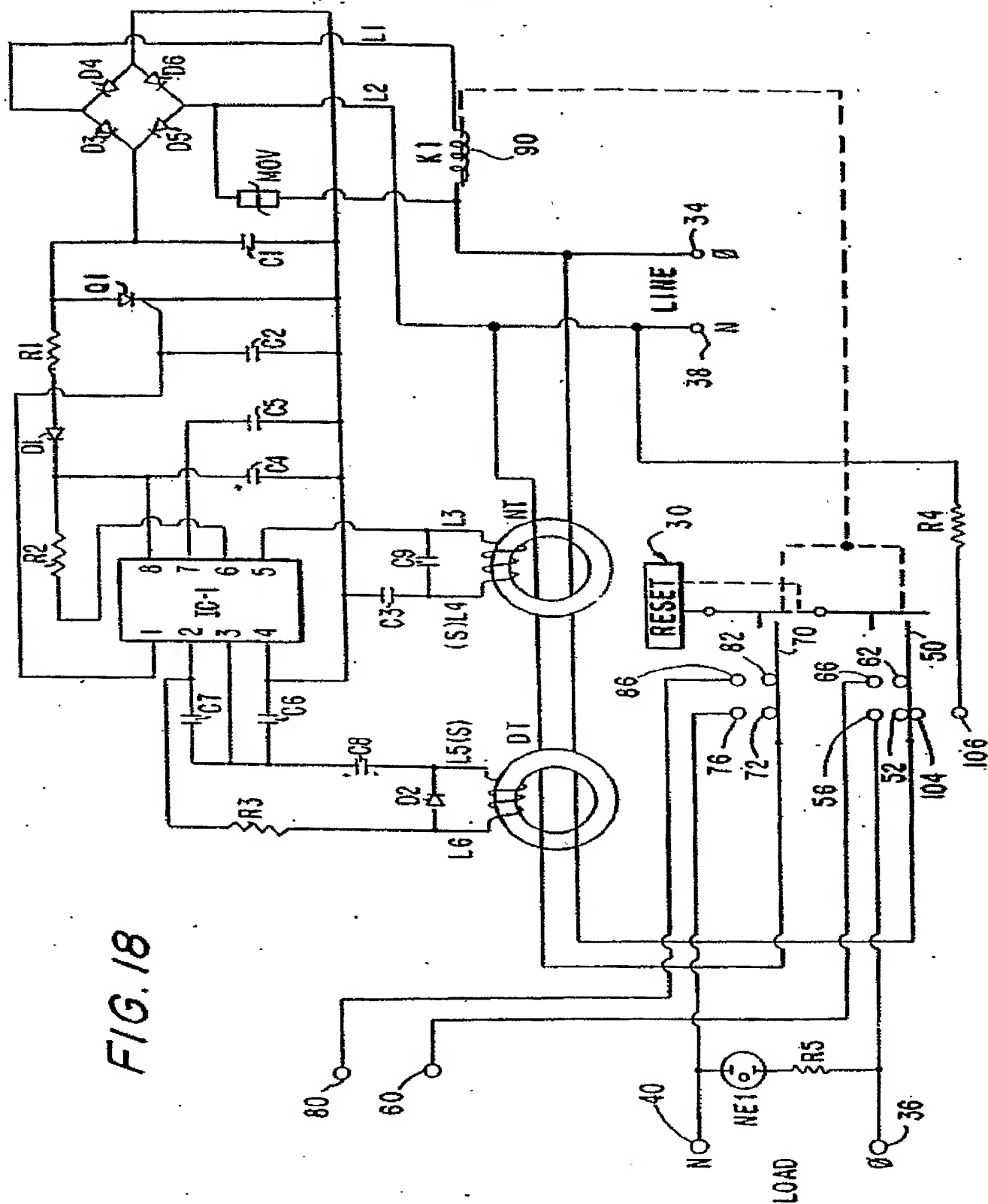
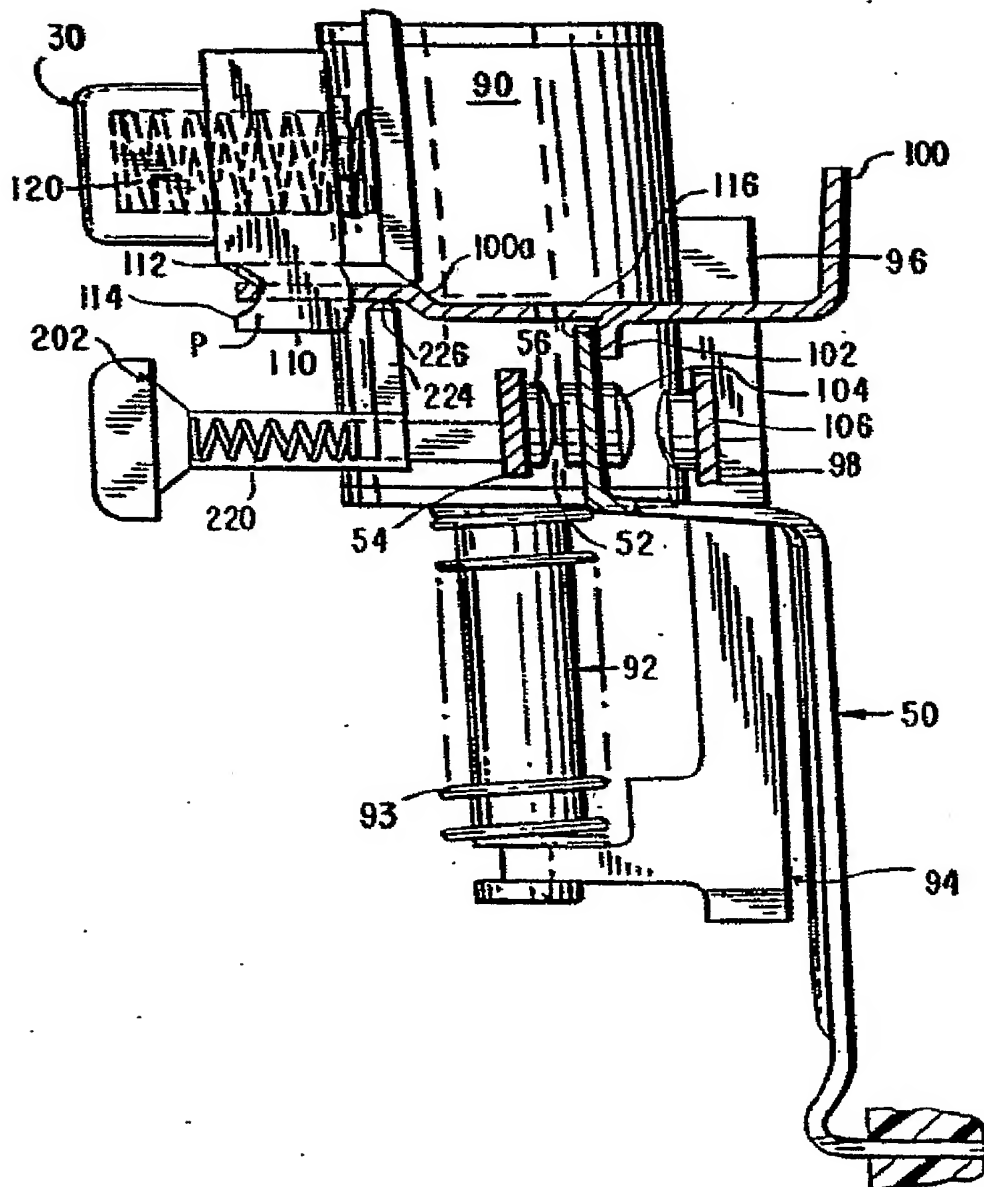


FIG. 18

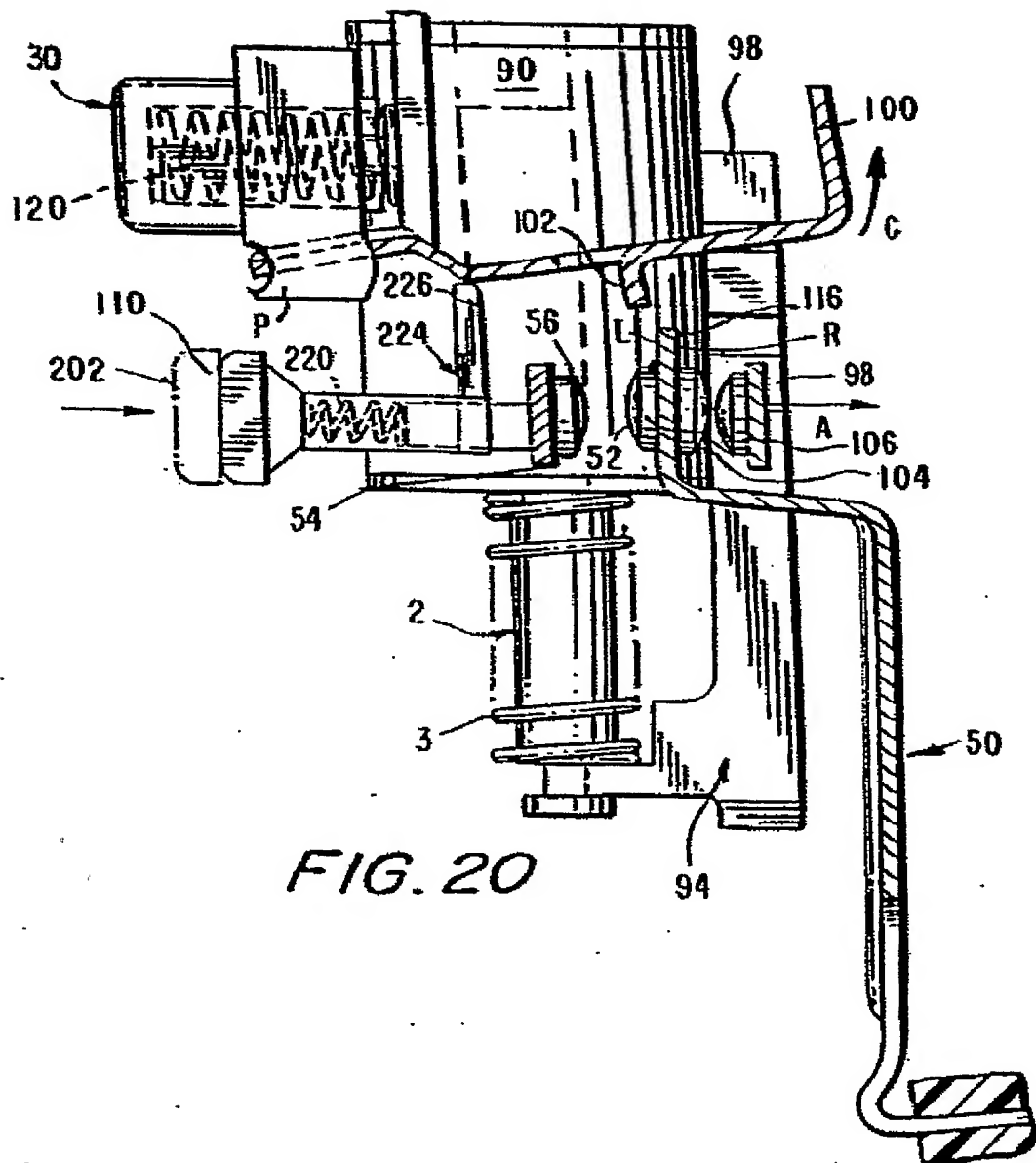
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FIG. 19



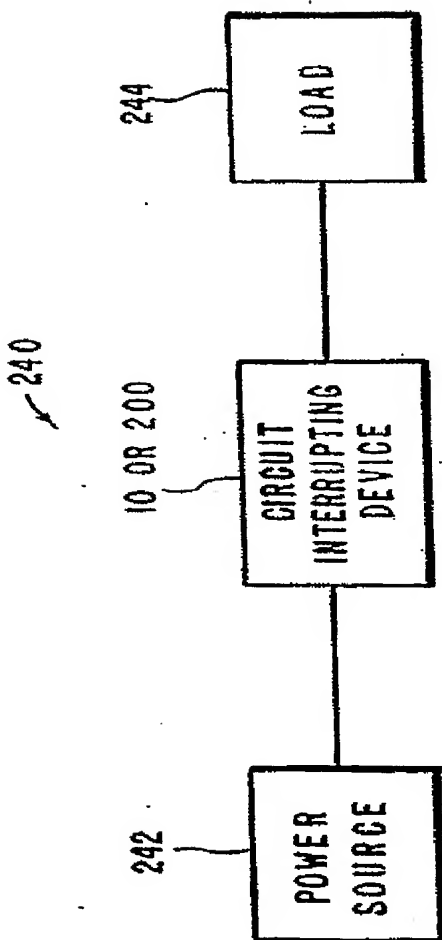


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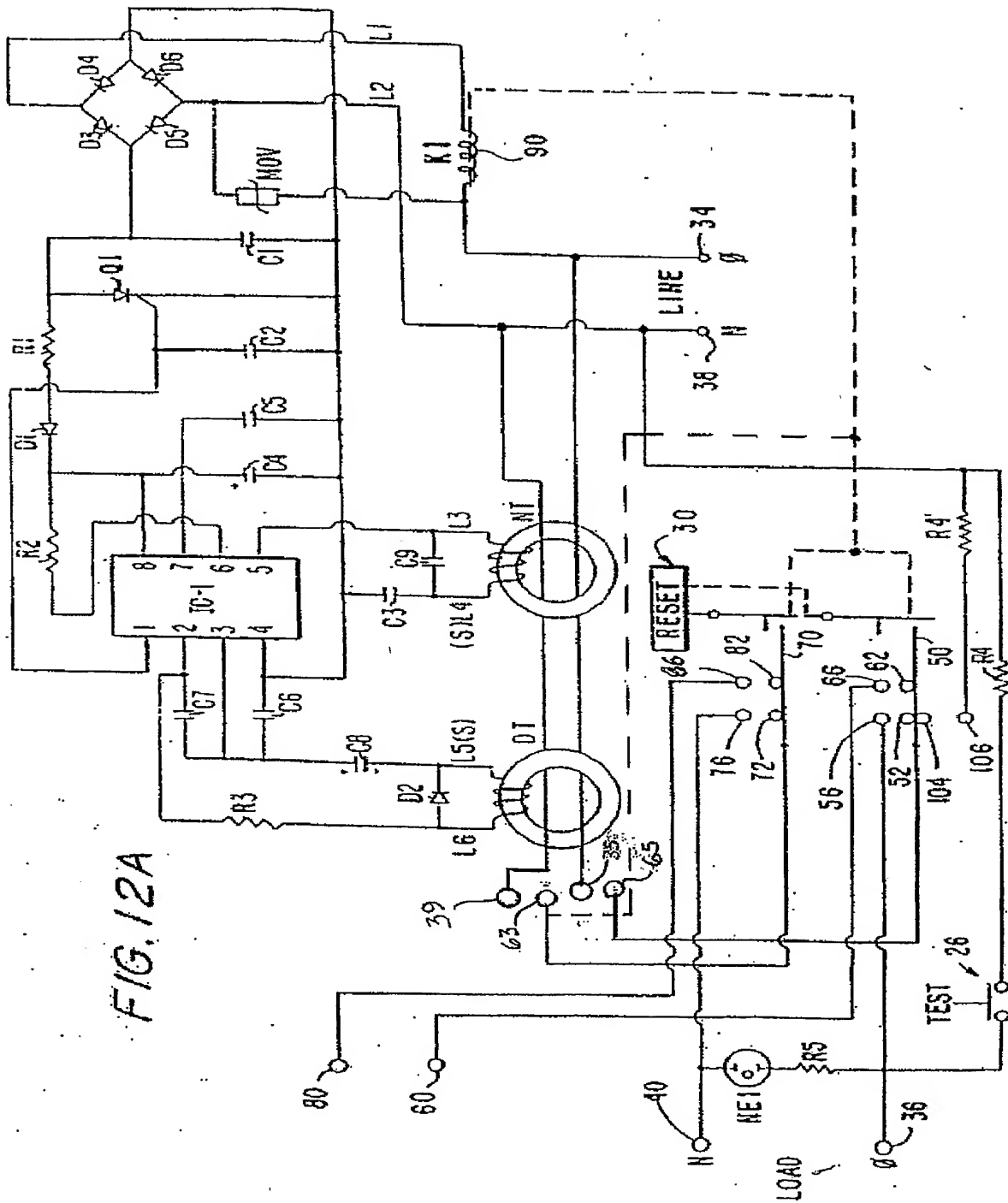


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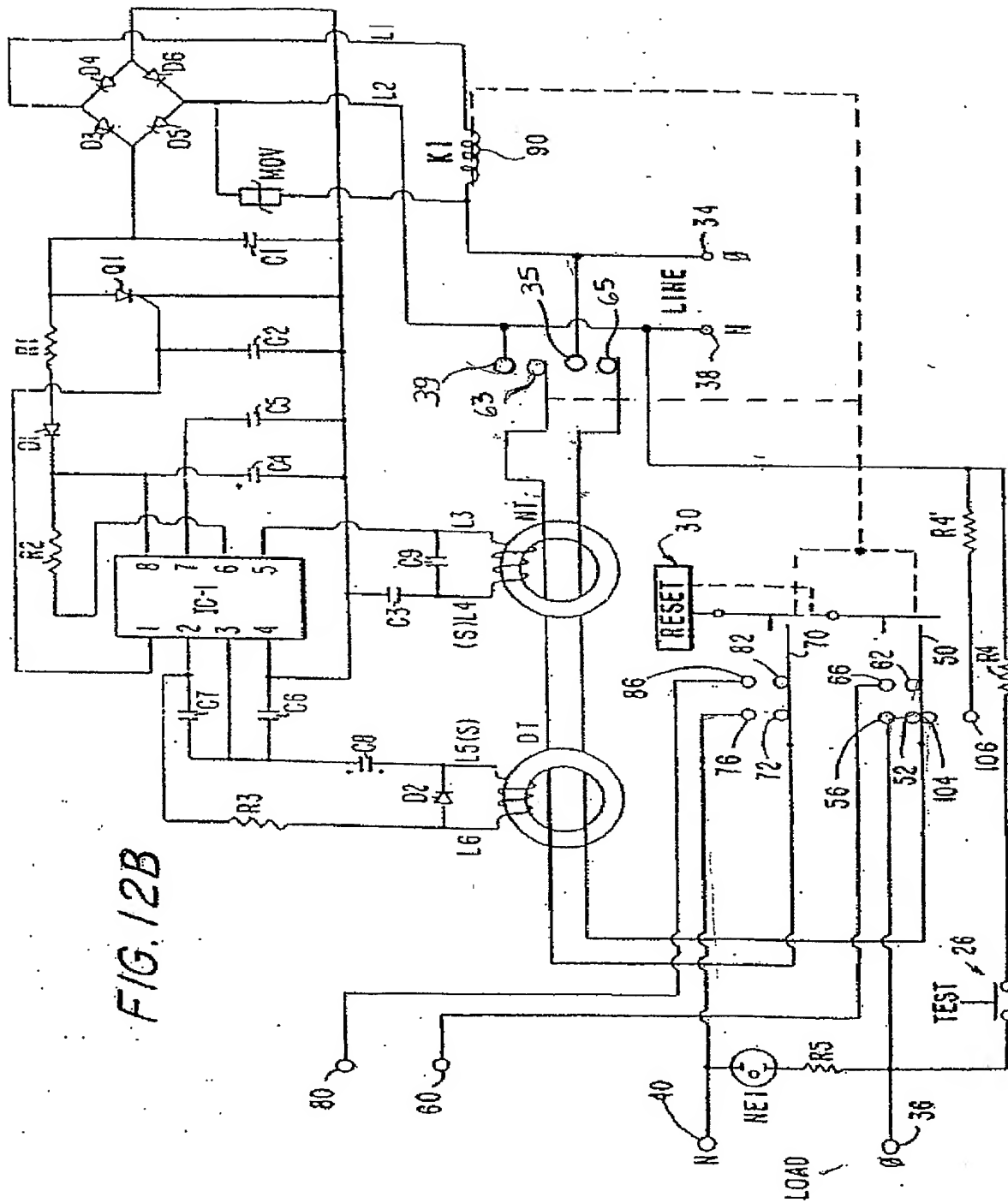
FIG. 21



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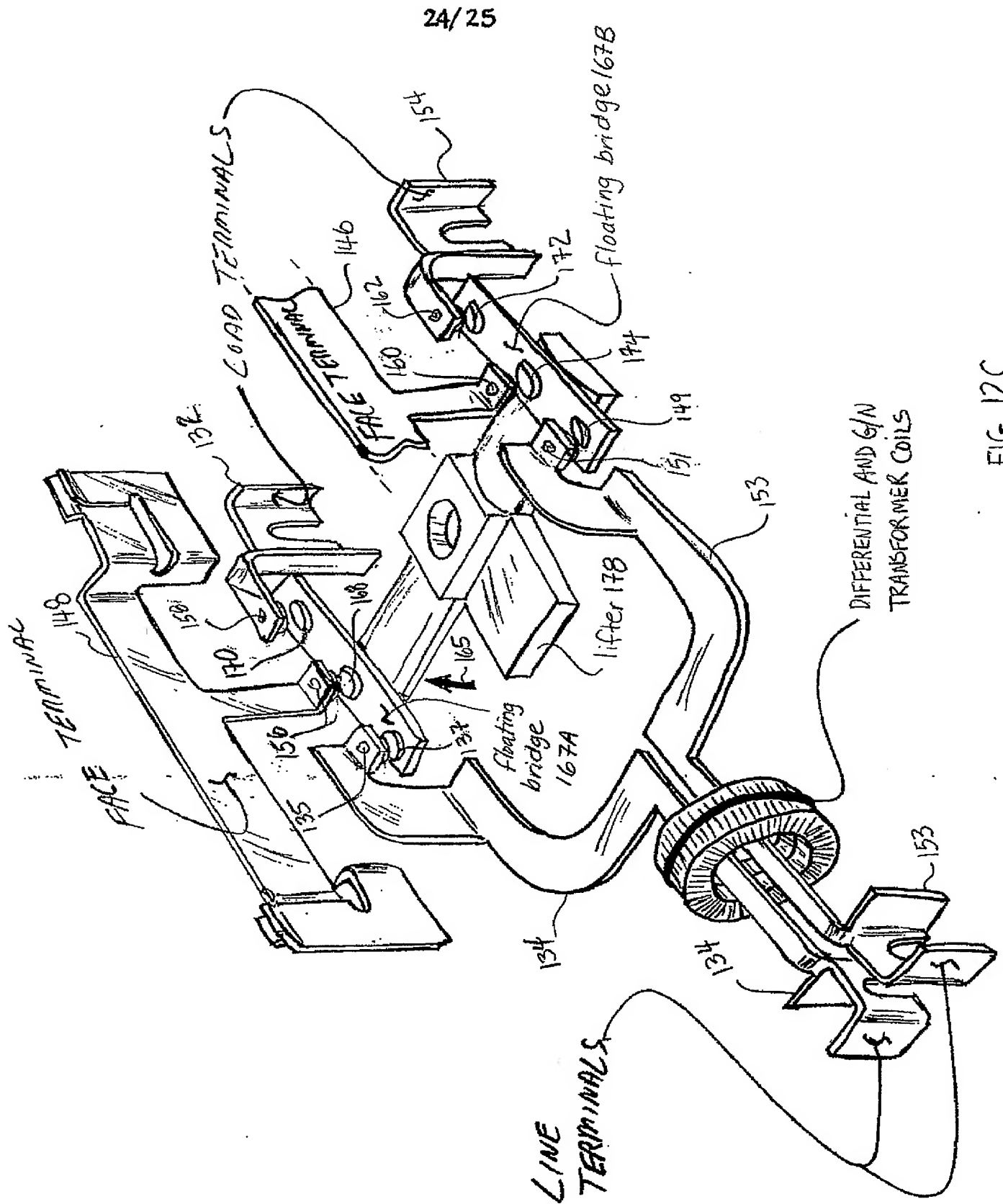


FIG 12C

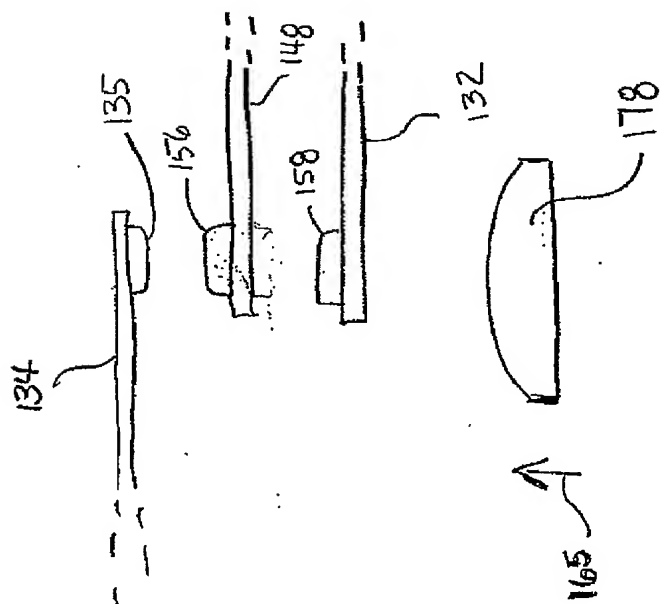


FIG. 12D

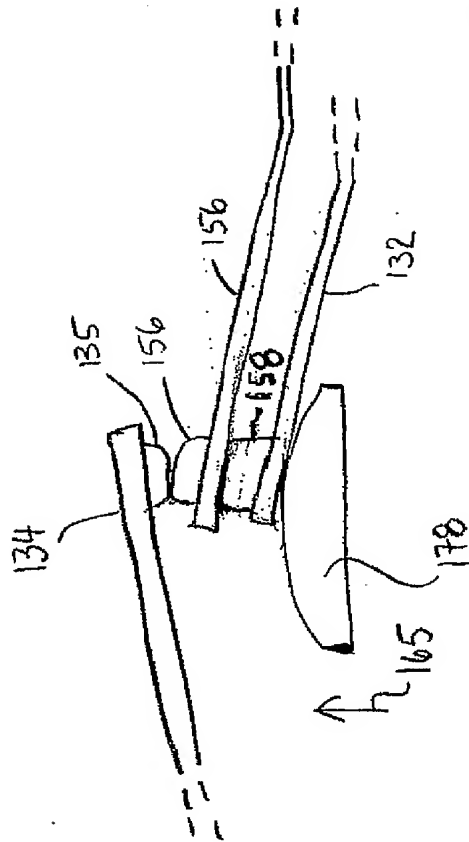


FIG. 12E